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TITLE: System for controlling distance to a vehicle traveling ahead based on an adjustable probability distribution

Abstract Text (1):
An intervehicle distance control system for automotive vehicles is provided which includes a laser scanning type distance sensor for scanning a laser beam in a width-wise direction of a system vehicle to determine relative positions and relative angles of objects within a forward detectable zone and determines same lane probabilities that the objects exist in the same lane of a road as the system vehicle using a variable probability distribution based on the relative positions and the relative angles of the objects. A target preceding vehicle is then selected from the objects based on the same lane probabilities for controlling the speed of the system vehicle to maintain a distance to the target preceding vehicle constant.

Brief Summary Text (3):
The present invention relates generally to an intervehicle distance control system for automotive vehicles. More particularly, the invention relates to an intervehicle distance control system including a radar system designed to detect a preceding vehicle traveling ahead for maintaining an intervehicle distance between the preceding vehicle and a controlled system vehicle at a given value under cruise control.

Brief Summary Text (5):
An automotive intervehicle distance control system is well known in the art which measures a relative speed of a preceding vehicle to a system vehicle and a distance to the preceding vehicle to hold the distance at a set value.

Brief Summary Text (6):
Such a system usually includes a preceding vehicle detector which measures the distance to a preceding vehicle. A preceding vehicle detector of this type normally includes a laser radar unit. The laser radar unit, however, has the drawback in that, if the direction of a laser beam is fixed, it becomes impossible to radiate the laser beam a long distance when a system vehicle is traveling on a curved road, thereby causing a vehicle moving on a different traffic lane as well as billboards or reflectors arranged along the road to be identified as a target vehicle traveling ahead on the same traffic lane.

Brief Summary Text (7):
For avoiding the above drawback, there has been proposed a scan type laser radar which scans a laser beam over a given zone. Additionally, there has been proposed a curve detector which determines whether an obstacle existing on a curve in the road detected by a scan type laser radar is a vehicle moving on the same traffic lane or not. For example, Japanese Patent First Publication No. 4-248489 teaches a preceding vehicle detecting system which determines whether an obstacle present ahead is a preceding vehicle or not based on the radius of a curve calculated using a steered angle. The drawback is, however, encountered in that, if there is a difference between the calculated radius and an actual radius of the curve, it will cause the preceding vehicle to be lost or another obstacle to be tracked as a target vehicle.

Brief Summary Text (8):
Further, Japanese Patent First Publication No. 6-176300 (corresponding to U.S. patent application Ser. No. 08/162,276, filed on Dec. 7, 1993, assigned to the same assignee

as that of this application) teaches a unique concept that it is determined whether an object tracked by a radar is a preceding vehicle or not using a preceding vehicle probability. This prior art, however, uses a fixed beam type laser radar and has the disadvantage that the preceding vehicle probability has no information on the width-wise direction of the system vehicle. Specifically, the preceding vehicle probability is used on the assumption that data disappears when the preceding vehicle moves in the width-wise direction of the system vehicle.

Brief Summary Text (11):
It is another object of the present invention to provide an intervehicle distance control system which includes a scan type radar unit detecting objects ahead of a system vehicle and selects a target preceding vehicle out of the detected objects using an adjustable same lane probability that the target preceding vehicle exists on the same lane as the system vehicle.

Brief Summary Text (12):
According to one aspect of the present invention, there is provided a system for controlling an intervehicle distance between a system vehicle equipped with the system and a preceding vehicle present ahead of the system vehicle which comprises (a) a speed measuring means for measuring a speed of the system vehicle, (b) a beam scanning means for scanning a beam over a given scanning angle in a width-wise direction of the system vehicle and receiving beams reflected from objects present within a forward detection zone defined by the scanning angle to detect the objects, (c) a distance and angular position determining means for determining distances to and angular positions of the objects in the forward detection zone based on the reflected beams, (d) a relative position and speed determining means for determining relative positions and relative speeds of the objects to the system vehicle based on the distances and the angular positions of the objects determined by the distance and angular position determining means, (e) a curve determining means for determining a degree of a curve in a road on which the system vehicle is traveling, (f) a same lane probability determining means for determining same lane probabilities of the objects being present in the same traffic lane as the system vehicle based on the degree of the curve determined by the curve determining means and the relative positions of the objects determined by the relative position and speed determining means, (g) a target preceding vehicle selecting means for selecting a target preceding vehicle out of the objects in the forward detection zone based on the same lane probabilities determined by the same lane probability determining means, and (h) an intervehicle distance control means for controlling an intervehicle distance between the system vehicle and the target preceding vehicle selected by the target preceding vehicle selecting means, the intervehicle distance means controlling the speed of the system vehicle measured by the speed measuring means to control the intervehicle distance.

Brief Summary Text (13):
In the preferred mode of the invention, the curve determining means includes (a) a steered angle detecting means for detecting a steered angle of the system vehicle at given control cycles, (b) an average steered angle determining means for determining an average steered angle at the given control cycles based on the steered angle detected by the steered angle detecting means, the average steered angle determining means updating the average steered angle based on the average steered angle determined one control cycle earlier and the steered angle detected by the steered detecting means at a current control cycle, (c) a straight travel determining means for determining whether the system vehicle is traveling straight or not based on a variation in the steered angle detected by the steered angle detecting means, (d) a neutral steered angle learning means for learning the steered angles of the system vehicle detected by the steered angle detecting means at given learning cycles when the straight travel determining means determines that the system vehicle is traveling straight to determine a neutral steered angle, and (e) a curve degree determining means for determining the degree of the curve of the road based on a deviation between the neutral steered angle determined by the neutral steered angle learning means and the average steered angle determined by the average steered angle determining means.

Brief Summary Text (22):
The curve degree determining means determines the degree of the curve of the road based on a deviation between the neutral steered angle determined by the neutral steered angle learning means and the average steered angle determined by the average

steered angle determining means when a first condition where the speed of the system vehicle measured by the speed measuring means is greater than a predetermined speed and a given number of the learning cycles expire is encountered. The deviation between the neutral steered angle and the average steered angle is decreased when a second condition different from the first condition is encountered.

Brief Summary Text (23):
The same lane probability determining means includes (a) a same lane probability distribution map representing a probability that an object present ahead of the system vehicle exist in the same traffic lane on a straight road as that in which the system vehicle is traveling based on a relative position of the object to the system vehicle, (b) a relative position converting means for converting the relative positions of the objects determined by the relative position and speed determining means into relative positions of the objects to the system vehicle if the objects exit on the straight road based on the degree of the curve determined by the curve determining means, and (c) an instantaneous same lane probability determining means for determining instantaneous probabilities that the objects detected by the beam scanning means exist in the same traffic lane as the system vehicle by look-up using the same lane probability distribution map based on the relative positions convened by the relative position converting means. The same lane probability determining means determines the same lane probabilities of the objects based on the instantaneous probabilities.

Brief Summary Text (32):
The relative position and speed determining means determines whether the objects detected by the beam scanning means are moving object or stationary objects based on the relative speeds of the objects and the speed of the system vehicle. The target preceding vehicle selecting means includes (a) a target moving preceding vehicle selecting means for selecting from among the same lane probabilities greater than a first probability the greatest one as a reference probability, selecting from among the moving objects showing the same lane probabilities within a given range over the reference probability and the moving objects showing the same lane probabilities greater than a second probability one of the smallest distance between itself and the system vehicle as a target moving preceding vehicle, and determining that there is no target moving preceding vehicle if the reference probability is not selected, (b) a target stationary preceding vehicle selecting means for selecting from among the stationary objects showing the same lane probabilities greater than a third probability one of the smallest distance between itself and the system vehicle as a target stationary preceding vehicle and determining that there is no target stationary preceding vehicle if there is no stationary objects showing the same lane probabilities greater than the third probability, and (c) a target preceding vehicle determining means for determining as the target preceding vehicle either of the target moving preceding vehicle and the target stationary preceding vehicle which has the smaller of the distances to the system vehicle, if either of the target moving preceding vehicle and the target stationary preceding vehicle is selected, the selected one being determined as the target preceding vehicle, If both the target moving preceding vehicle and the target stationary preceding vehicle are not selected, the target preceding vehicle determining means determining that there is no target preceding vehicle.

Brief Summary Text (34):
The intervehicle distance control means includes (a) a target intervehicle distance determining means for determining a target intervehicle distance to the target preceding vehicle based on an input from a system operator, (b) a target change rate of speed determining means for determining a target change rate of the speed of the system vehicle based on the relative speed of the target preceding vehicle and a difference between the distance to the target preceding vehicle determined by the distance and angular position determining means and the target intervehicle distance, (c) a target vehicle speed determining means for determining a target vehicle speed and updating the target vehicle speed at given control cycles based on the target vehicle speed determined one control cycle earlier and the target change rate determined by the target change rate, and (d) a speed control means for controlling the speed of the system vehicle to agree with the target vehicle speed.

Brief Summary Text (35):
The target intervehicle distance determining means determines a target intervehicle

distance time which includes a variable and a given initial value. The variable is changed based on an input from a system operator. The target intervehicle distance is determined by multiplying the target intervehicle distance time by the speed of the system vehicle measured by the speed measuring means.

Brief Summary Text (36):
The target intervehicle distance is defined within a range from given upper to lower limit.

Brief Summary Text (37):
The target vehicle speed determining means increases a response rate of the target vehicle speed is increased when the relative speed of the target preceding vehicle determined by the relative position and speed determining means is changed from an acceleration to a deceleration and vice versa.

Brief Summary Text (38):
When a system operator does not accelerate or decelerate the system vehicle, the target vehicle speed determining means limits the target vehicle speed within a range including the speed of the system vehicle measured by the speed measuring means below a set vehicle speed set under cruise control performed when intervehicle distance control by the intervehicle distance control means is not performed.

Brief Summary Text (39):
When the target preceding vehicle selecting means determines that there is no target preceding vehicle and when the speed of the system vehicle measured by the speed measuring means is greater than the target vehicle speed, the target vehicle speed determining means sets the target vehicle speed to the speed of the system vehicle and then updates the target vehicle speed based on the target vehicle speed determined one control cycle earlier and the target change rate determined by the target change rate. When the target preceding vehicle selecting means determines that there is no target preceding vehicle and when the speed of the system vehicle measured by the speed measuring means is smaller than the target vehicle speed, the target vehicle speed determining means determines the target vehicle speed based on an initial value indicating the target vehicle speed and updates the target vehicle speed based on the target vehicle speed determined one control cycle earlier and the target change rate determined by the target change rate. The target vehicle speed is limited within a range below a set vehicle speed set under cruise control performed when intervehicle distance control by the intervehicle distance control means is not performed.

Brief Summary Text (41):
The relative position and speed determining means determines whether the objects detected by the beam scanning means are moving objects, stationary objects, or obstacles on a side of the road based on the relative speeds of the objects and the speed of the system vehicle. The same lane probability determining means monitors a relative position of one of the obstacles to the system vehicle or one of the moving objects or the stationary objects to determine whether a lane exists on either side of the system vehicle or not. A result of the determination is used to modify the same lane probabilities.

Brief Summary Text (42):
When a turn indicator of the system vehicle is turn on, the same lane probability determining means shifts the center of the determination of the target preceding vehicle to a direction indicated by the turn indicator according to the speed of the system vehicle.

Brief Summary Text (43):
The same lane probability determining means decreases the same lane probability of the target preceding vehicle when the turn indicator is turned on.

Brief Summary Text (44):
When the turn indicator of the system vehicle is turned on, the same lane probability determining means shifts the center of the determination of the target preceding vehicle to a direction indicated by the turn indicator according to the speed of the system vehicle by correcting at least one of the degree of the curve determined by the curve determining means and components of the relative positions of the objects in a

lateral direction of the system vehicle so as to decrease the same lane probabilities of the objects in the direction indicated by the turn indicator according to the speed of the system vehicle.

Brief Summary Text (48):
A navigation system using a GPS (Global Positioning System) may be provided. When the target preceding vehicle selecting means determines that the curve exists in a forward direction based on data provided by the navigation system, the objects located at a given distance away from the system vehicle are not selected as the target preceding vehicle.

Brief Summary Text (49):
The initial value of the target intervehicle distance time is determined based on an intervehicle distance to the target preceding object selected by the target preceding vehicle selecting means when the intervehicle distance control means is not in operation.

Brief Summary Text (50):
The target intervehicle distance determining means increases the target intervehicle distance to the target preceding vehicle for a given period of time after the target preceding vehicle is selected.

Brief Summary Text (51):
When the number of objects detected by the beam scanning means is greater than a given value, the target intervehicle distance determining means decreases the target intervehicle distance to the target preceding vehicle.

Brief Summary Text (52):
The speed control means performs cruise control. When a system operator increases a set speed in the cruise control, the target change rate of speed determining means sets the target change rate of the speed of the system vehicle to a first acceleration value. When the system operator decreases the set speed in the cruise control, the target change rate of speed determining means sets the target change rate of the speed of the system vehicle to a given deceleration value. When the target preceding vehicle is not selected by the target preceding vehicle selecting means and when the system operator does not change the set speed in the cruise control, the target change rate of speed determining means sets the target change rate of the speed of the system vehicle to a second acceleration value smaller than the first acceleration value. Within a given period of time after the system driver increases the set speed in the cruise control, the target change rate of speed determining means sets the target change rate of the speed of the system vehicle to the first acceleration value.

Brief Summary Text (54):
When the target preceding vehicle is not selected by the target preceding vehicle selecting means and when the turn indicator of the system vehicle is turned on to indicate a direction from a passing lane to a traveling lime, the target change rate of speed determining means decreases the target change rate of the speed.

Brief Summary Text (55):
When the target preceding vehicle is not selected by the target preceding vehicle selecting means and when the turn indicator of the system vehicle is turned on to indicate a direction from a traveling lane to a passing lane, the target change rate of speed determining means increases the target change rate of the speed.

Brief Summary Text (56):
The target change rate of speed determining means determines whether the system vehicle is traveling on a downhill road or not. When the system vehicle is determined as being traveling on the downhill road, the target change rate of speed determining means decreases the target change rate of the speed.

Brief Summary Text (57):
The target change rate of speed determining means decreases the target change rate of the speed as the same lane probability of the target preceding vehicle is lowered.

Brief Summary Text (58):

The target change rate of speed determining means decreases an absolute value of the target change rate of the speed when the target intervehicle distance determined by the target intervehicle distance determining means is greater than a given distance.

Brief Summary Text (59):
The speed control means prohibits the speed of the system vehicle from increasing until the intervehicle distance to the target preceding vehicle exceeds the target intervehicle distance determined by the target intervehicle distance determining means by a given distance.

Brief Summary Text (60):
A weather condition detecting means is further provided for detecting a given weather condition degrading an operation of the beam scanning means. An intervehicle distance control prohibiting means is provided for prohibiting an operation of the intervehicle distance control means when the given weather condition is detected. An alarm means is provided for issuing an alarm when the operation of the intervehicle distance control means is prohibited.

Brief Summary Text (61):
A control operation informing means is provided for informing the system operator that the intervehicle distance control means is in operation.

Drawing Description Text (4):
FIG. 1 is a block diagram which shows an intervehicle distance control system according to the present invention;

Drawing Description Text (8):
FIG. 4 is a flowchart which shows a distance control routine performed by an intervehicle distance control system;

Drawing Description Text (11):
FIG. 7 is an illustration which shows a curved road for explanation of a neutral position learning process;

Drawing Description Text (16):
FIG. 12 is a flowchart which shows a target preceding vehicle selection routine;

Drawing Description Text (17):
FIG. 13 is a flowchart which shows a target intervehicle distance determination routine;

Drawing Description Text (19):
FIG. 15 is a table which shows parameters for determining a basic acceleration/deceleration value MDV in terms of the relation between a intervehicle distance deviation De and a relative speed Vr;

Drawing Description Text (20):
FIG. 16 is a graph which shows the relation between a correction coefficient KMDV and an intervehicle distance D;

Drawing Description Text (22):
FIG. 18 is an illustration which shows a curvature of a road determined using loci of a stationary object relative to a system vehicle;

Drawing Description Text (23):
FIG. 19 is an illustration which shows loci of a stationary object relative to a system vehicle for determining a curvature of a road;

Drawing Description Text (24):
FIG. 20 is an explanatory view for determining a curvature of a road using the loci of the stationary object shown in FIGS. 18 and 19;

Drawing Description Text (26):
FIG. 22 is a flowchart which shows an intervehicle distance learning routine used in a modification of intervehicle distance control.

Detailed Description Text (2):
Referring now to the drawings, wherein like numbers refer to like parts in several views, particularly to FIG. 1, there is shown an intervehicle distance control system 2 according to the present invention which may be incorporated in an automotive vehicle powered by an internal combustion engine.

Detailed Description Text (3):
The intervehicle distance control system 2 is designed to maintain an intervehicle distance between a system vehicle equipped with this system and a preceding vehicle at a set distance under cruise control and includes a control unit 4 provided with a computer, a laser scanning type distance sensor 6, a steering angle sensor 8, a vehicle speed sensor 10, a cruise control switch unit 12, an indicator unit 14, an automatic transmission controller 16, a brake unit 18, and a throttle unit 20.

Detailed Description Text (4):
The control unit 4 includes an input/output interface and various driver circuits and detection circuits whose hardware is well known in the art, and explanation thereof in detail will be omitted here. The control unit 4 performs conventional cruise control to maintain the vehicle speed constant at a pre-set speed in the absence of a preceding vehicle within a forward detection zone.

Detailed Description Text (6):
The steering angle sensor 8 monitors a change in steered angle of a steering wheel. When a power source of the intervehicle distance control system 2 is turned on, "0" is set at a steered angle address of a memory of the control unit 4, and monitored changes in steered angle are summed up to determine a relative steered angle. Additionally, a steered angle while the vehicle is traveling straight is determined in a mariner, as described later in detail, and then defined as a reference value for determination of curve data. The steering angle sensor 8 used in this embodiment has a resolution of 2.25.degree..

Detailed Description Text (8):
The cruise control switch unit 12 includes a main switch 12a, a set switch 12b, a resuming switch 12c, a cancel switch 12d, and a tap switch 12e. The main switch 12a is for starting the cruise control. When the main switch 12a is turned on, the cruise control is performed and intervehicle distance control is also performed. When the set switch 12b is actuated, the control unit 4 measures a vehicle speed Vn and then sets it as a target speed Vm of the cruise control. The resuming switch 12c, if actuated when the cruise control is not in operation and the target speed Vm is stored, returns the current vehicle speed to the target speed Vm. The cancel switch 12d, If actuated during the cruise control, stops the cruise control. The tap switch 12e is, as discussed later in detail, for setting an intervehicle distance between the system vehicle and a target preceding vehicle.

Detailed Description Text (9):
The indicator unit 14 includes a set vehicle speed indicator 14a, a current intervehicle distance indicator 14b, a set intervehicle distance time indicator 14c, and a sensor malfunction indicator 14d. The set vehicle speed indicator 14a indicates a set speed under the cruise control. The current intervehicle distance indicator 14b indicates an intervehicle distance to a target preceding vehicle selected in a manner, as described later, based on the distance measured by the distance sensor 6. The set intervehicle distance time indicator 14c indicates a time distance for controlling the intervehicle distance in a manner, as described later. The sensor malfunction indicator 14d indicates malfunctions of various sensors such as the distance sensor 6 etc.

Detailed Description Text (12):
The throttle unit 20 includes a throttle actuator 20a and a throttle valve position sensor 20b. The throttle actuator 20a is responsive to a command from the control unit 4 to regulate an opening degree of a throttle valve of the internal combustion engine to control the engine power. The throttle valve position sensor 20b detects the opening degree of the throttle valve. For example, a determination of whether the system vehicle is traveling on a downhill road or not may be made by comparing the vehicle speed and the opening degree of the throttle valve.

Detailed Description Text (14):
Internally, the control unit 4, as shown in FIG. 2, includes a coordinate transformation circuit 4a, a sensor malfunction detecting circuit 4b, an object identifying circuit 4d, a vehicle speed calculating circuit 4c, a steered angle calculating circuit 4e, a curvature calculating circuit 4f, a same lane probability calculating circuit 4g, a preceding vehicle selecting circuit 4h, and an intervehicle distance control circuit 4i.

Detailed Description Text (19):
The curvature calculating circuit 4f determines a curvature R of a road based on the vehicle speed derived by the vehicle speed calculating circuit 4c and the steered angle .theta.0 derived by the steered angle calculating circuit 4e. The same lane probability calculating circuit 4g determines a probability that a preceding vehicle tracked by the distance sensor 6 is traveling on the same traffic lane as the system vehicle based on the curvature R, the type of the object, the object width W, the x-y coordinates of the center of the object derived by the object identifying circuit 4d. The preceding vehicle selecting circuit 4h selects a target preceding vehicle among from objects tracked by the distance sensor 6 based on the curvature R, the same lane probability, the type of object, the relative speed and the x-y coordinates of the center of the object to determine a distance to and a relative speed Vr of the selected target preceding vehicle.

Detailed Description Text (20):
The intervehicle distance control circuit 4i provides control signals to the brake actuator 18a, the throttle actuator 20a, and the automatic transmission controller 16 based on the distance to the target preceding vehicle, the relative speed Vr, the vehicle speed Vn, switching conditions of the cruise control switch unit 12, and a signal from the brake switch 18b for regulating the distance to the target preceding vehicle, and also provides an indicator signal to the indicator unit 14 to inform the driver of current control conditions.

Detailed Description Text (22):
The intervehicle distance control circuit 4i, as shown in FIG. 3(b), includes a target intervehicle distance calculating section 30, a target acceleration/deceleration calculating section 32, a target vehicle speed calculating section 34, a control mode determining section 36, and a vehicle speed control section 38. The intervehicle distance control unit 4i of this embodiment, as will be apparent from the drawing, regulates the opening degree of the throttle valve through the throttle actuator 20a for controlling an intervehicle distance, but it may control the brake actuator 18a and the automatic transmission controller 16 based on detected data for accelerating or decelerating the system vehicle to avoid collision with an object ahead of the system vehicle.

Detailed Description Text (23):
The target intervehicle distance calculating section 30 determines a target intervehicle distance based on switching conditions of the cruise control switch unit 12 and the vehicle speed Vn. However, in this embodiment, a target intervehicle distance time, which will be discussed later in detail, is first determined before the target intervehicle distance is determined and then multiplied by the vehicle speed Vn to determine the target intervehicle distance. The target acceleration/deceleration calculating section 32 determines a target acceleration/deceleration value based on the target intervehicle distance, the switching conditions of the cruise control switch unit 12, a distance to and a relative speed of the target preceding vehicle. The target vehicle speed calculating section 34 then determines a target vehicle speed Vm based on the target acceleration/deceleration value and the switching conditions of the cruise control switch unit 12. The control mode determining section 36 then determines whether throttle valve fully closing control should be performed or not based on the target vehicle speed Vm and the actual vehicle speed Vn. If control of the brakes and the automatic transmission is also required, the control mode determining section 36 determines whether the control of the brakes and the automatic transmission should be performed or not.

Detailed Description Text (26):
After entering the program, the routine proceeds to step 1000 wherein distances to and

angles of objects tracked by the intervehicle distance sensor 6 are read in the control unit 4. The routine then proceeds to step 2000 wherein a type of each object, the object width W, x-y coordinates of the center of the object, and the relative speed Vr are determined. For example, if a relative position of the object is hardly changed although the system vehicle is traveling, the object is identified as a moving object. In addition, if the object is moving away from the system vehicle, it is also identified as the moving object. Alternatively, if the relative position of the object approaching the system vehicle at the same speed as that of the system vehicle, the object is identified as a stationary object. In other cases, for example, if a given period of time sufficient for distinguishing the type of the object does not expire, the object is determined as an unidentified object. These object identifying techniques are well known in the art.

Detailed Description Text (55):
The reason why the actual steered angle .theta. is set to zero (0) in the equation (15) is that a steered angle of a vehicle during traveling at a low speed on a curved road is usually small. The actual steered angle .theta. may alternatively be corrected by the equation (14) regardless of the vehicle speed and the learning degree counter value Cst.

Detailed Description Text (56):
After step 3300, the routine proceeds to step 3400 wherein the curvature R of a road is determined according to the equation (16) below.

Detailed Description Text (57):
where f(Vn) is a function determined by motion characteristics of a vehicle which are well known in the art as a function for determining a radius of a curved road based on a steered angle, and explanation thereof in detail will be omitted here.

Detailed Description Text (59):
First, in step 4010, instantaneous same lane probabilities of the objects detected by the distance sensor 6 are determined in the following manner. The central positions (X0, Y0) and the object widths (W0) of all objects obtained in step 2000 are converted into parameters in terms of a straight road. Specifically, a road having the curvature R obtained in step 3000 is mathematically transformed into a straight road and then coordinates of each object if it exists on the straight road are determined. This transformation is given by the following equations.

Detailed Description Text (61):
The parameters (X, Y, W) of each object thus derived are then plotted on a same lane probability distribution map shown in FIG. 11 to determine the instantaneous same lane probability, that is, a probability that the object now exists in the same traffic lane as the system vehicle. It is because a difference, or error usually exits between the curvature R determined based on the steered angle and the actual curvature of the road.

Detailed Description Text (83):
After the same lane probability of each object is determined in the above manner in step 4000, the routine proceeds to step 5000 wherein from among the objects having the same lane probabilities P determined in step 4000, a target preceding vehicle is selected according to steps, as shown in FIG. 12.

Detailed Description Text (84):
First, in step 5010, the objects are classified into moving objects and stationary objects, and one traveling preceding vehicle is selected out of the moving objects in a manner as discussed below. The routine then proceeds to step 5020 wherein one stationary preceding vehicle is selected out of the stationary objects in a manner as discussed below.

Detailed Description Text (85):
SELECTION OF TRAVELING PRECEDING VEHICLE (Step 5010)

Detailed Description Text (90):
The reason that the object having a smaller same lane probability P is selected as an absolute value of the curvature R is decreased is because it becomes more difficult to

find a preceding vehicle as the absolute value of the curvature R is decreased. (2) If a plurality of objects are selected in the above step (1), from among moving objects having same lane probabilities P greater than the maximum same lane probability minus 15% or moving objects having same lane probabilities P greater than 70%, one having the smallest value of Y0 is selected as a traveling preceding vehicle.

Detailed Description Text (91):
If no moving object is selected in the step (1), it is concluded that there is no preceding vehicle traveling in front of the system vehicle.

Detailed Description Text (93):
(1) From among the stationary objects having same lane probabilities P more than or equal to 70% (P.gtoreq.70%), one having the smallest value of Y0 is selected as a stationary preceding vehicle. If no stationary object is selected, it is concluded that there is no stationary preceding vehicle in front of the system vehicle. Note that the selecting condition of the stationary objects is more severe than that of the moving objects for preventing obstacles on the sides of a road from being identified as preceding vehicles.

Detailed Description Text (94):
After steps 5020, the routine proceeds to step 5020 wherein a target preceding vehicle is ultimately selected from the traveling preceding vehicle determined in step 5010 and the stationary preceding vehicle determined in step 5020 in the following manner.

Detailed Description Text (95):
(1) If both the traveling preceding vehicle and the stationary preceding vehicle do not exist in front of the system vehicle, it is concluded that there is no preceding vehicle within the forward detectable zone.

Detailed Description Text (96):
(2) If either the traveling preceding vehicle or the stationary preceding vehicle exists, it is selected as the target preceding vehicle.

Detailed Description Text (97):
(3) If both the traveling preceding vehicle and the stationary preceding vehicle exist, one having a smaller value of Y0 is selected as the target preceding vehicle.

Detailed Description Text (98):
Therefore, even if the target preceding vehicle is mistakenly selected or has been lost out of the forward detectable zone, it is not objectionable because the latest target preceding vehicle is selected from among a plurality of objects tracked by the distance sensor 6 every control cycle.

Detailed Description Text (99):
After the target preceding vehicle is determined in steps 1000 to 5000, the intervehicle distance control is initiated in step 6000.

Detailed Description Text (100):
After entering step 6000, the routine proceeds to step 6010 shown in FIG. 13 wherein it is determined whether the program operation is a first control activation immediately after the power source is turned on or not. If a YES answer is obtained, then the routine proceeds to step 6020 wherein an initial value T0 is provided as a target intervehicle distance time TH. The initial value T0 is set to 2.5 sec., for example.

Detailed Description Text (102):
The tap down operation is such that the vehicle operator or driver actuates the tap switch 12e of the cruise control switch unit 12 for increasing an intervehicle distance to the target preceding vehicle. Conversely, the tap up operation is such that the driver actuates the tap switch 12e for decreasing the intervehicle distance.

Detailed Description Text (103):
If a YES answer is obtained in step 6030 meaning that the tap down operation has been performed, then the routine proceeds to step 6060 wherein the target intervehicle distance time TH is increased according to the following relation.

Detailed Description Text (104):
After step 6060, the routine proceeds to step 6070 wherein it is determined whether the target intervehicle distance time TH is greater than 3.3 sec. or not. If a YES answer is obtained, then the routine proceeds to step 6080 wherein the target intervehicle distance time TH is set to an upper limit of 3.3 sec. Alternatively, if a NO answer is obtained in step 6070, then the routine proceeds directly to step 6050.

Detailed Description Text (105):
If a YES answer is obtained in step 6040 meaning that the tap up operation has been performed, then the routine proceeds to step 6090 wherein the target intervehicle distance time TH is decreased according to the following relation.

Detailed Description Text (106):
The routine then proceeds to step 6100 wherein it is determined whether the target intervehicle distance time TH is smaller than 0.7 sec. or not. If a YES answer is obtained, then the routine proceeds to step 6110 wherein the target intervehicle distance time TH is set to a lower limit of 0.7 sec. Alternatively, if a NO answer is obtained in step 6100, then the routine proceeds directly to step 6050.

Detailed Description Text (107):
In step 6050, the target intervehicle distance time TH is converted into a target intervehicle distance Dt using the vehicle speed Vn according to the equation (35) below.

Detailed Description Text (109):
After entering step 7000, the routine proceeds to step 7010 shown in FIG. 14 wherein it is determined whether the system vehicle is in a coast operation or not. If a NO answer is obtained, then the routine proceeds to step 7020 wherein it is determined whether the system vehicle is in an acceleration operation or not. If a NO answer is obtained, then the routine proceeds to step 7030 wherein it is determined whether the target preceding vehicle has been selected or not.

Detailed Description Text (112):
If the system vehicle is not both in the coast operation and in the acceleration operation meaning that the target preceding vehicle has been selected in step 5000, then a YES answer is obtained in step 7030. The routine then proceeds to step 7040 wherein a basic acceleration/deceleration value is determined in the following manner.

Detailed Description Text (113):
(1) First, an intervehicle distance deviation De is mathematically determined using a distance D to the target preceding vehicle and the target intervehicle distance Dt obtained in step 6050 according to the equation (36) below.

Detailed Description Text (114):
(2) Next, the basic acceleration/deceleration value MDV (km/h/s) is determined by interpolating mapped parameters shown in FIG. 15 using the intervehicle distance deviation De and the relative speed Vr. For hysteresis, dead bands of 2 m are provided between adjacent boundaries of the mapped parameters of the intervehicle distance deviation De, while dead bands of 1 km/h are provided between adjacent boundaries of the mapped parameters of the relative speed Vr. If a value of the intervehicle distance deviation De and a value of the relative speed Vr are out of the mapped ranges, a value within the closest range is selected as the basic acceleration/deceleration value MDV.

Detailed Description Text (115):
Note that even if the intervehicle distance deviation De indicates a negative value (-), an acceleration value (i.e., the basic acceleration/deceleration value MDV>0) is selected as long as the speed of the target preceding vehicle is higher than that of the system vehicle (Vr>0) so that the target preceding vehicle is traveling away from the system vehicle. This is because there is no need for decelerating the system vehicle as long as the target preceding vehicle is moving away from the system vehicle.

Detailed Description Text (116):
Subsequently, the routine proceeds to step 7050 wherein a correction coefficient KMDV for the basic acceleration/deceleration value MDV is determined from the relation, as shown in FIG. 16, to the intervehicle distance D for preventing the intervehicle distance control system 2 from responding to a distant preceding vehicle sensitively.

Detailed Description Text (133):
Several modifications of the above intervehicle distance control will be discussed below.

Detailed Description Text (136):
First, upon detecting a stationary object, loci thereof relative to the system vehicle are monitored at regular time intervals. The loci are then defined as an arc to calculate the curvature R of a road on which the system vehicle is traveling. If an absolute value of the curvature R is more than a given value (e.g., 1500 m), a difference between the neutral steered angle .theta.c and the actual steered angle .theta. is determined and then cumulated every control cycle. If an absolute value of the cumulative value exceeds a given value and if the cumulative value is positive, a given value is subtracted from the neutral steered angle .theta.c. The given value is preferably set to 1/10 of a resolution of the steering angle sensor 8, for example, 0.225.degree., if the resolution is 2.25.degree.. Alternatively, if the cumulative value is negative, the given value is added to the neutral steered angle .theta.c.

Detailed Description Text (151):
(1) If an object identified as an obstacle (i.e., a stationary object of the object width W different from that of a vehicle) on the side of a road in step 2000 exists immediately in front of the system vehicle and if an absolute value of the curvature R, as determined above based on the loci of the stationary object, is small, it may be determined that the road is curved sharply and that the setting condition for the learning prohibiting counter value Cgs is satisfied. This improves the reliability of the neutral steered angle .theta.c, allowing the target preceding vehicle to be tracked with higher accuracy.

Detailed Description Text (152):
(2) If an object (e.g., a guardrail) is detected in Step 2000 which exists immediately in front of the system vehicle and which has a length extending in a longitudinal direction of the system vehicle, it may be determined that the road is curved sharply and that the setting condition for the learning prohibiting counter value Cgs is satisfied. This further improves the learning of a steered angle while the system vehicle is traveling straight.

Detailed Description Text (154):
In order to achieve a more accurate determination of a preceding vehicle, the instantaneous same lane probability in step 4010 may be determined or corrected in the following steps (1) to (3).

Detailed Description Text (155):
(1) A relative position(s) of a stationary object(s), as identified in step 2000 as an obstacle(s) (e.g., a guardrail) on the side(s) of a road, to the system vehicle or a preceding vehicle is monitored to determine whether a space of a traffic lane exists on either side of the system vehicle or the preceding vehicle or not. For example, if the obstacle exists immediately on the left side of the system vehicle or a preceding vehicle, it is determined that there is no lane on the left side of the system vehicle or the preceding vehicle and that the system vehicle or the preceding vehicle is traveling in the left lane of a road if it has two lanes. Alternatively, if the obstacles exist both sides of the system vehicle or the preceding vehicle, it is determined that the system vehicle or the preceding vehicle is traveling on a road having only one lane.

Detailed Description Text (157):
(3) The analyses of the above steps (1) and (2) are used in determining the instantaneous same lane probability. For example, since a moving object having the object width W equal to that of a vehicle, tracked by the distance sensor 6 while the system vehicle is traveling on a road having only one lane will be a preceding vehicle moving on the same lane as the system vehicle, the instantaneous same lane probability

is increased.

Detailed Description Text (159):
When a turn indicator is turned on, the center of determination of the target preceding vehicle may be shifted to a direction indicated by the turn indicator according to the speed of the system vehicle. For example, while in step 4010, the central positions (X0, Y0) and the object widths (W0) of all objects obtained in step 2000 are converted into parameters (X, Y, W) in terms of a straight road, respectively, and then plotted on the same lane probability map shown in FIG. 11 to determine the instantaneous same lane probability of each object, the curvature R used in the equation (17) may be increased when the turn indicator indicates the right direction and decreased when the turn indicator indicates the left direction. This prevents the system vehicle from being decelerated undesirably when it shifts to a right adjacent lane and passes a preceding vehicle because the speed of the preceding vehicle is too slow. Further, if another vehicle exists in the adjacent lane to which the system vehicle is veering, it can be identified as a preceding vehicle quickly.

Detailed Description Text (164):
This achieves more accuracy anti-collision action to prevent the system vehicle from colliding with a preceding vehicle traveling at a speed slower than that of the system vehicle.

Detailed Description Text (166):
If an object detected in step 2000 is small, it may be presumed to be a vehicle such as a motorcycle. Since a motorcycle usually travels on either side of a road, the instantaneous same lane probability of the motorcycle may be increased for safety. For example, if the following conditions are all satisfied, it is determined that a small object such as a motorcycle is traveling in front of the system vehicle, and several tens percent (e.g., about 30%) is added to the instantaneous same lane probability P0 of the motorcycle.

Detailed Description Text (173):
The detection of a curve only based on outputs from the steered angle sensor 8 may cause the same lane probability P of a preceding vehicle to be small, resulting in error in determining the preceding vehicle as a vehicle traveling ahead of the system vehicle when the system vehicle is traveling straight and the preceding vehicle traveling in the same lane as the system vehicle enters the curve. Accordingly, it is advisable that such a condition be detected based on the magnitude of a relative speed Vrx in a width-wise direction (i.e., a direction of the x-axis) to increase the time constant of the instantaneous same lane probability, as discussed above. When the system vehicle enters the curve following the preceding vehicle, the relative speed Vrx in the width-wise direction is decreased. Thus, the time constant is returned to its initial value. The time constant is, however, not increased when the preceding vehicle is in close proximity to the system vehicle (e.g., within 40 m) for quickly responding to another vehicle pulling in front of the system vehicle. This prevents a preceding vehicle from being lost and another vehicle traveling in an adjacent lane from being identified as a target preceding vehicle, which would be caused by a decrease in the instantaneous same lane probability at the entrance to the curve.

Detailed Description Text (175):
where dX /dt indicates an x-component of the relative speed Vr of the preceding vehicle and d(Y.multidot.Y/2R)/dt indicates an x-component of a change rate of the center of the lane in which the system vehicle is traveling.

Detailed Description Text (177):
If another vehicle nips in between the system vehicle and a preceding vehicle being tracked, the cruise control may be performed regardless of the same lane probability P of the tracked preceding vehicle. The nipping of the vehicle is detected by monitoring movement thereof in a width-wise direction. Thus, it is possible to determine the vehicle which has nipped in front of the system vehicle as a target preceding vehicle quickly before the same lane probability thereof becomes great. This allows the cruise control to be performed quickly.

Detailed Description Text (179):
A navigation system using a GPS (Global Positioning System) may be incorporated in the

intervehicle distance control system 2. Using map information of the navigation system derived based on current positional data of the system vehicle from the GPS, it is possible to determine whether a curve exists in a forward direction of the system vehicle or not. If the curve exists in the forward direction, distant objects located at a given distance away from the system vehicle may not be determined as preceding vehicles. This determination is preferably made before or after step 5030 in FIG. 12. This prevents the instantaneous same lane probability P0 from being increased to perform the intervehicle distance control undesirably, which is caused by the fact that a vehicle traveling in an adjacent lane on a curved road ahead of the system vehicle traveling straight is detected as existing substantially in front of the system vehicle.

Detailed Description Text (181):
In steps 6030, 6040, and 6060 to 6110 of the target intervehicle distance determination process, the target intervehicle distance Dt is, as already discussed, determined by a driver's manual operation of the tap switch 12e. The manual operation of the tap switch 12e is usually performed when the initial value T0 of the target intervehicle distance time TH set in step 6020 is of no interest to the driver, but it is quite troublesome because the operation of the tap switch 12e must be performed at least one time before the intervehicle distance control is initiated.

Detailed Description Text (182):
For avoiding the above drawback, a program, as shown in a flowchart of FIG. 22, may be carried out in stead of steps 6020, 6040, and 6060 to 6110 or in addition to these steps to learn an intervehicle distance of interest to the driver when the intervehicle distance control is not performed.

Detailed Description Text (183):
After executing step 6200 wherein a target preceding vehicle is determined in the same manner as that performed in steps 1000 to 5000, the routine proceeds to step 6210 wherein an intervehicle distance between the system vehicle and the target preceding vehicle is determined using positional coordinates of the target preceding vehicle obtained in step 2000 and then divided by the speed of the system vehicle to find an intervehicle distance time Ta. The routine then proceeds to step 6220 wherein a frequency of the intervehicle distance time Ta obtained in this control cycle which is stored in one of memory locations of a memory in the control unit 4 is incremented for defining a frequency distribution of the intervehicle distance time Ta.

Detailed Description Text (184):
The routine then proceeds to step 6230 wherein the intervehicle distance time Ta showing the greatest frequency is selected or an average value is determined by weighting the intervehicle distance times Ta with the frequencies thereof. The routine then proceeds to step 6240 wherein the value determined in step 6230 is set as the initial value T0 which is used in step 6020 upon initiation of the intervehicle distance control operation. This minimizes the need for the driver to operate the tap switch 12e.

Detailed Description Text (185):
Frequency distributions of the intervehicle-distance time Ta may be determined for every vehicle speed. Vn in step 6220. The intervehicle distance time Ta showing the greatest frequency in one of the frequency distributions corresponding to the vehicle speed Vn in this control cycle or an average value determined in a similar manner to that discussed above is set to the initial value T0 in step 6020.

Detailed Description Text (187):
Upon initiation of the intervehicle distance control, the target intervehicle distance Dt (or the target intervehicle distance time TH) may be increased for a given period of time according to the distance to the target preceding vehicle when tracked in step 2000 for avoiding close proximity to the target preceding vehicle if the detection of the target preceding vehicle is delayed undesirably.

Detailed Description Text (188):
For example, the target intervehicle distance time TH may be increased before step 6050. Alternatively, in or after step 6050, the target intervehicle distance Dt may be increased.

Detailed Description Text (190):
Usually, when a plurality of vehicles (e.g., 3 or 4 vehicles) exist ahead of the system vehicle, they may be considered as being traveling in a group. Thus, the target intervehicle distance Dt may be decreased in the following manner.

Detailed Description Text (191):
In, before, or after step 6050, an average value of the number of traveling vehicles being tracked for several seconds (e.g., 3 sec.) is determined based on data in step 2000. If the average value is more than three, the target intervehicle distance time TH (or the target intervehicle distance Dr) is shortened using a correction coefficient Kd (0<Kd<1) according to the following equation (49).

Detailed Description Text (192):
where Tmn is a minimum intervehicle distance time, for example, 0.7 sec.

Detailed Description Text (193):
This realizes the fact that ordinary drivers bring their vehicles close to preceding vehicles intentionally when they travel on a congested road.

Detailed Description Text (195):
When preceding vehicles are unidentified, the acceleration/deceleration value At is, as explained above, set to a constant positive value (i.e., an acceleration value) in step 7080, but it may alternatively be limited to a safe value based on the steered angle .theta.0, a lateral acceleration G, or a traveling road radius for decreasing the vehicle speed Vn to within a safe range.

Detailed Description Text (203):
In stead of the map shown in FIG. 15, a plurality of maps may be used according to the length of the target intervehicle distance Dt. For example, when the target intervehicle distance Dt is relatively longer, a map for maintaining the vehicle speed constant, for example, a map providing a constant value of the basic acceleration/deceleration value MDV regardless of a difference between the intervehicle distance deviation De and the relative speed Vr, is used, while when the target intervehicle distance Dt is relatively shorter, a map for maintaining the intervehicle distance constant, for example, a map changing the basic acceleration/deceleration value MDV greatly according to a difference between the intervehicle distance deviation De and the relative speed Vr, is used. This establishes a good drive feeling.

Detailed Description Text (205):
In stead of the map shown in FIG. 15, a plurality of maps may be used according to the degree of the vehicle speed Vn. For example, when the vehicle speed Vn is relatively low, a map for increasing a control response rate, for example, a map changing the basic acceleration/deceleration value MDV greatly according to a difference between the intervehicle distance deviation De and the relative speed Vr, is used, while when the vehicle speed Vn is relatively high, a map for decreasing the control response rate, for example, a map providing substantially a constant value of the basic acceleration/deceleration value MDV regardless of a difference between the intervehicle distance deviation De and the relative speed Vr, is used. This also establishes a good drive feeling.

Detailed Description Text (207):
The acceleration/deceleration value At may be decreased if the system vehicle is determined as being traveling on a downhill road. Specifically, during a time when the system vehicle is traveling on the downhill road, if the acceleration/deceleration value At indicates a positive value (i.e., an acceleration), it is decreased, while if the acceleration/deceleration value At indicates a negative value (i.e., a deceleration), it is increased. For example, it may be determined that the system vehicle is traveling on the downhill road if a determination that the throttle valve is closed to a given extent is made by comparing the relation between the vehicle speed Vn and the opening degree of the throttle valve detected by the throttle valve position sensor 20b with the relation therebetween when the system vehicle travels on a level road. If it is determined that the system vehicle is traveling on the downhill road, the acceleration/deceleration value At is changed to a smaller value after step

7040. This avoids overspeed of the system vehicle during traveling on the downhill road.

Detailed Description Text (209):
The acceleration/deceleration value At may be corrected based on the same lane probability P of the target preceding vehicle after step 7040. For example, an absolute value of the acceleration/deceleration value At is decreased as the same lane probability P is lowered. This minimizes an error in tracking a vehicle traveling in an adjacent lane. It is, however, advisable that when the relative speed Vr is negative, the correction not be performed for avoiding the collision with a preceding vehicle approaching the system vehicle.

Detailed Description Text (211):
An absolute value of the acceleration/deceleration value Ta may be decreased after step 7040 when the target intervehicle distance Dt is longer than a given distance. This is because usually, a distant vehicle is not felt to be dangerous and also does not induce the driver to track it.

Detailed Description Text (213):
Once the throttle valve is fully closed, the system vehicle may be prohibited from accelerating until the following relation (50) between the actual intervehicle distance D and the target intervehicle distance Dt is met.

Detailed Description Text (216):
The equation (50) may alternatively be expressed in terms of an intervehicle distance time.

Detailed Description Text (218):
If a preceding vehicle tracked by the distance sensor 6 is determined as an unidentified object, the target vehicle speed Vm may be set to a current vehicle speed or the vehicle speed Vn.

Detailed Description Text (219):
While in step 8010, the target vehicle speed Vm is decreased to decrease the speed of the system vehicle if the preceding vehicle is slower than the system vehicle, in step 7080, the decreased target vehicle speed Vm is increased gradually if the preceding vehicle disappears out of the forward detectable zone during a time when the target vehicle speed Vm is lower than the vehicle speed Vn. This consumes a longer time until the system vehicle is accelerated. Therefore, a control response rate is improved by setting the target vehicle speed Vm to a current vehicle speed or the vehicle speed Vn if a preceding vehicle is determined as an unidentified object. Note that Vm.ltoreq.Vs that is a cruise control set speed.

Detailed Description Text (221):
If it is possible that the system vehicle is in close proximity to a preceding vehicle, causing an accidental collision, the current intervehicle distance indicator 14b of the indicator unit 14 or a buzzer (not shown) may be used to alert the driver to the possibility of collision in step 1000 or 2000.

Detailed Description Text (223):
When the system vehicle is decelerated quickly under the Intervehicle distance control, a brake lamp (not shown) may be turned on to inform a trailing vehicle that the system vehicle is being decelerated for avoiding a rear-end collision with the trailing vehicle.

Detailed Description Text (225):
If it is in bad weather conditions, the intervehicle distance control may be prohibited.

Detailed Description Text (226):
Usually, the rain, snow, and fog lower the performance of the distance sensor 6, thereby making it difficult to detect preceding vehicles. It is, therefore, advisable that a weather sensor be provided in the intervehicle distance control system 2 to monitor weather conditions for prohibiting the intervehicle distance control until the weather is improved. As the weather sensor, a sensor which optically detects the

amount of particles floating in the air or a sensor which detects drops of water based on a change in conductivity may be used. It is also advisable that the driver be Informed of the prohibition of the intervehicle distance control through the Indicator unit 14.

Detailed Description Text (228):
When a target preceding vehicle is selected out of objects tracked by the distance sensor 6 to switch a control mode from the cruise control to the intervehicle distance control, a lamp (not shown) mounted in the indicator unit 14 or the current intervehicle distance indicator 14b may be turned on and off to inform the driver of the change of the control mode. Alternatively, it is advisable that the color of back light of a display of the indicator unit 14 be changed upon switching of the control mode between the cruise control and the intervehicle distance control. This is because it is difficult for the driver to determine the timing of depressing the brake pedal if the driver does not know whether a target preceding vehicle is tracked by the intervehicle distance control system 2 in steps 1000 to 5000 to have the system vehicle undergo the intervehicle distance control or not. If the driver can perceive through the indicator unit 14 that the intervehicle distance control is not performed when a vehicle is traveling ahead of the system vehicle, it becomes possible for the driver to apply brakes with suitable timing for extra safety.

Detailed Description Text (230):
Even if the driver depresses the brake pedal when the speed of the system vehicle is higher than that of a target preceding vehicle, the system vehicle may be prohibited from accelerating without canceling the intervehicle distance control.

Detailed Description Text (231):
The conventional intervehicle distance control as well as the cruise control is canceled necessarily upon depression of the brake pedal. Resuming the control requires an manual operation of a resuming lever, which is quite inconvenience for the driver. The above control eliminates the need for the manual operation of the resuming lever to relieve driver's loads.

CLAIMS:

1. A system for controlling an intervehicle distance between a system vehicle equipped with the system and a preceding vehicle present ahead of the system vehicle comprising:

speed measuring means for measuring a speed of the system vehicle;

beam scanning means for scanning a beam over a given scanning angle in a width-wise direction of the system vehicle and receiving beams reflected from objects present within a forward detection zone defined by the scanning angle to detect the objects;

distance and angular position determining means for determining distances to and angular positions of the objects in the forward detection zone based on the reflected beams:

relative position and speed determining means for determining relative positions and relative speeds of the objects to the system vehicle based on the distances and the angular positions of the objects determined by said distance and angular position determining means;

curve determining means for determining a degree of a curve in a road on which the system vehicle is traveling;

same lane probability determining means for determining same lane probabilities of the objects being present in the same traffic lane as the system vehicle based on the degree of the curve determined by said curve determining means and the relative positions of the objects determined by said relative position and speed determining means;

target preceding vehicle selecting means for selecting a target preceding vehicle out of the objects in the forward detection zone based on the same lane probabilities

determined by said same lane probability determining means; and

intervehicle distance control means for controlling an intervehicle distance between the system vehicle and the target preceding vehicle selected by said target preceding vehicle selecting means, said intervehicle distance means controlling the speed of the system vehicle measured by said speed measuring means to control the intervehicle distance.

2. A system as set forth in claim 1, wherein said curve determining means includes:

steered angle detecting means for detecting a steered angle of the system vehicle at given control cycles;

average steered angle determining means for determining an average steered angle at the given control cycles based on the steered angle detected by said steered angle detecting means, said average steered angle determining means updating the average steered angle based on the average steered angle determined one control cycle earlier and the steered angle detected by said steered detecting means at a current control cycle:

straight travel determining means for determining whether the system vehicle is traveling straight or not based on a variation in the steered angle detected by said steered angle detecting means;

neutral steered angle learning means for learning the steered angles of the system vehicle detected by said steered angle detecting means at given learning cycles when said straight travel determining means determines that the system vehicle is traveling straight to determine a neutral steered angle; and

curve degree determining means for determining the degree of the curve of the road based on a deviation between the neutral steered angle determined by said neutral steered angle learning means and the average steered angle determined by said average steered angle determining means.

11. A system as set forth in claim 2, wherein said curve degree determining means determines the degree of the curve of the road based on a deviation between the neutral steered angle determined by said neutral steered angle learning means and the average steered angle determined by said average steered angle determining means when a first condition where the speed of the system vehicle measured by said speed measuring means is greater than a predetermined speed and a given number of the learning cycles expire is encountered, and wherein the deviation between the neutral steered angle and the average steered angle is decreased when a second condition different from the first condition is encountered.

12. A system as set forth in claim 1, wherein said same lane probability determining means includes:

a same lane probability distribution map representing a probability that an object present ahead of the system vehicle exist in the same traffic lane on a straight road as that in which the system vehicle is traveling based on a relative position of the object to the system vehicle;

relative position converting means for converting the relative positions of the objects determined by said relative position and speed determining means into relative positions of the objects to the system vehicle if the objects exit on the straight road based on the degree of the curve determined by said curve determining means; and

instantaneous same lane probability determining means for determining instantaneous probabilities that the objects detected by said beam scanning means exist in the same traffic lane as the system vehicle by look-up using said same lane probability distribution map based on the relative positions converted by said relative position converting means,

and wherein said same lane probability determining means determines the same lane probabilities of the objects based on the instantaneous probabilities.

21. A system as set forth in claim 1, wherein said relative position and speed determining means determines whether the objects detected by said beam scanning means are moving object or stationary objects based on the relative speeds of the objects and the speed of the system vehicle,

and wherein said target preceding vehicle selecting means includes:

target moving preceding vehicle selecting means for selecting from among the same lane probabilities greater than a first probability the greatest one as a reference probability, selecting from among the moving objects showing the same lane probabilities within a given range over the reference probability and the moving objects showing the same lane probabilities greater than a second probability one of the smallest distance between itself and the system vehicle as a target moving preceding vehicle, and determining that there is no target moving preceding vehicle if the reference probability is not selected;

target stationary preceding vehicle selecting means for selecting from among the stationary objects showing the same lane probabilities greater than a third probability one of the smallest distance between itself and the system vehicle as a target stationary preceding vehicle and determining that there is no target stationary preceding vehicle if there is no stationary objects showing the same lane probabilities greater than the third probability; and

target preceding vehicle determining means for determining as the target preceding vehicle either of the target moving preceding vehicle and the target stationary preceding vehicle which has the smaller of the distances to the system vehicle, if either of the target moving preceding vehicle and the target stationary preceding vehicle is selected, the selected one being determined as the target preceding vehicle, if both the target moving preceding vehicle and the target stationary preceding vehicle are not selected, the target preceding vehicle determining means determining that there is no target preceding vehicle.

23. A system as set forth in claim 1, wherein said intervehicle distance control means includes:

target intervehicle distance determining means for determining a target intervehicle distance to the target preceding vehicle based on an input from a system operator;

target change rate of speed determining means for determining a target change rate of the speed of the system vehicle based on the relative speed of the target preceding vehicle and a difference between the distance to the target preceding vehicle determined by said distance and angular position determining means and the target intervehicle distance;

target vehicle speed determining means for determining a target vehicle speed and updating the target vehicle speed at given control cycles based on the target vehicle speed determined one control cycle earlier and the target change rate determined by said target change rate; and

speed control means for controlling the speed of the system vehicle to agree with the target vehicle speed.

24. A system as set forth in claim 23, wherein said target intervehicle distance determining means determines a target intervehicle distance time which includes a variable and a given initial value, the variable being changed based on an input from a system operator, the target intervehicle distance being determined by multiplying the target intervehicle distance time by the speed of the system vehicle measured by said speed measuring means.

25. A system as set forth in claim 24, wherein the target intervehicle distance is defined within a range from given upper to lower limit.

26. A system as set forth in claim 23, wherein said target vehicle speed determining means increases a response rate of the target vehicle speed is increased when the

relative speed of the target preceding vehicle determined by said relative position and speed determining means is changed from an acceleration to a deceleration and vice versa.

27. A system as set forth in claim 23, wherein when a system operator does not accelerate or decelerate the system vehicle, said target vehicle speed determining means limits the target vehicle speed within a range including the speed of the system vehicle measured by said speed measuring means below a set vehicle speed set under cruise control performed when intervehicle distance control by said intervehicle distance control means is not performed.

28. A system as set forth in claim 23, wherein when said target preceding vehicle selecting means determines that there is no target preceding vehicle and when the speed of the system vehicle measured by said speed measuring means is greater than the target vehicle speed, said target vehicle speed determining means sets the target vehicle speed to the speed of the system vehicle and then updates the target vehicle speed based on the target vehicle speed determined one control cycle earlier and the target change rate determined by said target change rate, when said target preceding vehicle selecting means determines that there is no target preceding vehicle and when the speed of the system vehicle measured by said speed measuring means is smaller than the target vehicle speed, said target vehicle speed determining means determining the target vehicle speed based on an initial value indicating the target vehicle speed and updating the target vehicle speed based on the target vehicle speed determined one control cycle earlier and the target change rate determined by said target change rate, and wherein the target vehicle speed is limited within a range below a set vehicle speed set under cruise control performed when intervehicle distance control by said intervehicle distance control means is not performed.

30. A system as set forth in claim 1, wherein said relative position and speed determining means determines whether the objects detected by said beam scanning means are moving objects, stationary objects, or obstacles on a side of the road based on the relative speeds of the objects and the speed of the system vehicle, and wherein said same lane probability determining means monitors a relative position of one of the obstacles to the system vehicle or one of the moving objects or the stationary objects to determine whether a lane exists on either side of the system vehicle or not, a result of the determination being used to modify the same lane probabilities.

31. A system as set forth in claim 1, wherein when a turn indicator of the system vehicle is turn on, said same lane probability determining means shifts the center of the determination of the target preceding vehicle to a direction indicated by the turn indicator according to the speed of the system vehicle.

32. A system as set forth in claim 31, wherein said same lane probability determining means decreases the same lane probability of the target preceding vehicle when the turn indicator is turned on.

33. A system as set forth in claim 1, wherein when a turn indicator of the system vehicle is turned on, said same lane probability determining means shifts the center of the determination of the target preceding vehicle to a direction indicated by the turn indicator according to the speed of the system vehicle by correcting at least one of the degree of the curve determined by said curve determining means and components of the relative positions of the objects in a lateral direction of the system vehicle so as to decrease the same lane probabilities of the objects in the direction indicated by the turn indicator according to the speed of the system vehicle.

37. A system as set forth in claim 1, further comprising a navigation system using a GPS (Global Positioning System), and wherein when said target preceding vehicle selecting means determines that the curve exists in a forward direction based on data provided by the navigation system, the objects located at a given distance away from the system vehicle are not selected as the target preceding vehicle.

38. A system as set forth in claim 23, wherein the initial value of the target intervehicle distance time is determined based on an intervehicle distance to the target preceding object selected by said target preceding vehicle selecting means when said intervehicle distance control means is not in operation.

39. A system as set forth in claim 23, wherein said target intervehicle distance determining means increases the target intervehicle distance to the target preceding vehicle for a given period of time after the target preceding vehicle is selected.

40. A system as set forth in claim 23, wherein when the number of objects detected by said beam scanning means is greater than a given value, said target intervehicle distance determining means decreases the target intervehicle distance to the target preceding vehicle.

41. A system as set forth in claim 23, wherein said speed control means performs cruise control, and wherein when a system operator increases a set speed in the cruise control, the target change rate of speed determining means sets the target change rate of the speed of the system vehicle to a first acceleration value, when the system operator decreases the set speed in the cruise control, the target change rate of speed determining means setting the target change rate of the speed of the system vehicle to a given deceleration value, when the target preceding vehicle is not selected by said target preceding vehicle selecting means and when the system operator does not change the set speed in the cruise control, the target change rate of speed determining means setting the target change rate of the speed of the system vehicle to a second acceleration value smaller than the first acceleration value, within a given period of time after the system driver increases the set speed in the cruise control, the target change rate of speed determining means setting the target change rate of the speed of the system vehicle to the first acceleration value.

43. A system as set forth in claim 23, wherein when the target preceding vehicle is not selected by said target preceding vehicle selecting means and when a turn indicator of the system vehicle is turned on to indicate a direction from a passing lane to a traveling lane, said target change rate of speed determining means decreases the target change rate of the speed.

44. A system as set forth in claim 23, wherein when the target preceding vehicle is not selected by said target preceding vehicle selecting means and when a turn indicator of the system vehicle is turned on to indicate a direction from a traveling lane to a passing lane, said target change rate of speed determining means increases the target change rate of the speed.

45. A system as set forth in claim 23, wherein said target change rate of speed determining means determines whether the system vehicle is traveling on a downhill road or not, and wherein when the system vehicle is determined as being traveling on the downhill road, said target change rate of speed determining means decreases the target change rate of the speed.

46. A system as set forth in claim 23, wherein said target change rate of speed determining means decreases the target change rate of the speed as the same lane probability of the target preceding vehicle is lowered.

47. A system as set forth in claim 23, wherein said target change rate of speed determining means decreases an absolute value of the target change rate of the speed when the target intervehicle distance determined by said target intervehicle distance determining means is greater than a given distance.

48. A system as set forth in claim 23, wherein said speed control means prohibits the speed of the system vehicle from increasing until the intervehicle distance to the target preceding vehicle exceeds the target intervehicle distance determined by said target intervehicle distance determining means by a given distance.

49. A system as set forth in claim 1, further comprising weather condition detecting means for detecting a given weather condition degrading an operation of said beam scanning means, intervehicle distance control prohibiting means for prohibiting an operation of said intervehicle distance control means when the given weather condition is detected, and alarm means for issuing an alarm when the operation of said intervehicle distance control means is prohibited.

50. A system as set forth in claim 1, further comprising control operation informing

means for informing a system operator that said intervehicle distance control means is in operation.

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L12: Entry 64 of 131 File: USPT Oct 3, 2000

DOCUMENT-IDENTIFIER: US 6127964 A
TITLE: Monitoring mechanism of obstacle detecting apparatus for vehicle

Brief Summary Text (4):
In recent days, there is a structure which has an obstacle detecting apparatus and an alarm in a vehicle traveling on a highway or the like, detects an obstacle existing on a traveling road by an obstacle detecting apparatus and informs an operator of an existence of the obstacle by the alarm. Further, in an unmanned dump truck which travels on a fixed course in a mine or the like, it is structured such as to detect the obstacle existing on the course by the obstacle detecting apparatus and automatically control the vehicle by a brake.

Brief Summary Text (7):
The receiving type is structured such that the outgoing device is omitted in the transmitting and receiving type mentioned above, and corresponds to a receiving side in a so-called beacon, however, in a structure for a vehicle, since the transmitting device can not be provided in all of many and unspecified obstacles (stones, rocks, cliffs, animals and the like) existing on a traveling road, in most cases, an image processing type is employed.

Brief Summary Text (29):
In accordance with the second aspect, the following operation and effect can be obtained. When the monitoring mechanism serves a monitoring function during a travel of the vehicle, a monitoring accuracy is affected by an oscillation of a vehicle body and the like. Further, first of all, the obstacle detecting device should be intent on searching the obstacle. Then, in the second aspect, the monitoring mechanism serves a monitoring function when the vehicle stop signal St is received from the vehicle stop detecting device. Accordingly, since the monitoring is not performed during the travel, it is possible to prevent the monitoring accuracy from changing due to the oscillation of the vehicle, and first of all, the obstacle detecting apparatus can be intent on searching the obstacle during the travel. In this case, the "stop time of the vehicle" detected by the vehicle stop detecting device can be exemplified by a neutral time of a transmission, an effective time of a parking brake, a stop time of an engine, a measured vehicle speed 0 time in the case of the vehicle having a vehicle speed meter, and the like.

Brief Summary Text (32):
In accordance with a fourth aspect, there is provided a monitoring mechanism of an obstacle detecting apparatus for a vehicle as cited in the first, second or third aspect, wherein a plurality of predetermined reflecting devices are arranged in medium path Lo-Li from the outgoing device to the incoming device.

Brief Summary Text (33):
In accordance with the fourth aspect, the following operation and effect can be obtained. In the first to third aspects mentioned above, no attention is paid to a number of the arranged predetermined reflecting devices. However, in accordance with the fourth aspect, the medium path Lo Li from the outgoing device to the incoming device becomes long, and a distance search error when operating the monitoring mechanism is cancelled at a lengthened degree, so that an accurate monitoring can be performed. Further, it is a specified example, however, in a structure of detecting the obstacle by frequency diffracting the millimeter wave by an FM-CW (FFT), a DC component (a direct current component) appears when the distance is near 0, so that

the predetermined reflecting device can not be detected. For example, in the obstacle detecting apparatus having a resolving power of 2 m, the medium path Lo-Li can not detect the obstacle having a size of about 3 m or less and the predetermined reflecting device. Even in this case, it is possible to lengthen the medium path Lo-Li so as to detect.

Brief Summary Text (45):
In accordance with the seventh aspect, since the outgoing device and the incoming device are integrally supported on the rotating device in a freely rotatable manner, it is possible to additionally obtain the effects (1) to (3) of the first aspect mentioned above. Further, in the same manner as the sixth aspect mentioned above, in accordance with the seventh aspect, it is possible to judge an abnormality of the obstacle detecting apparatus, the predetermined reflecting device and the rotating device without an existence of the vehicle stop detecting device, without arranging a plurality of predetermined reflecting devices in the medium path Lo-Li and without arranging the predetermined reflecting device on the rotating device.

Brief Summary Text (59):
In accordance with the ninth aspect, the following operation and effect can be obtained in the same manner as that of the second aspect. The monitoring mechanism serves a monitoring function when the vehicle stop signal St is received from the vehicle stop detecting device. Accordingly, since the monitoring is not performed during the travel, it is possible to prevent the monitoring accuracy from changing due to the oscillation of the vehicle, and first of all, the obstacle detecting apparatus can be intent on image pickup of the obstacle during the travel. In this case, the "stop time of the vehicle" detected by the vehicle stop detecting device corresponds to a neutral time of a transmission, an effective time of a parking brake, a stop time of an engine, a measured vehicle speed 0 time in the case of the vehicle having a vehicle speed meter, and the like, in the same manner as mentioned above.

Detailed Description Text (3):
An embodied apparatus mounting a first embodiment is a large-sized unmanned dump truck B (hereinafter, refer to as an own vehicle B) which runs on a fixed course A such as a mine and the like, as shown in FIG. 1. This has an own vehicle position and direction detecting device 1 which previously stores a course data and detects a position Pi and a direction Pd of the own vehicle B on the course A by means of a global positioning system (GPS) and an optical fiber gyroscope, an actuator 2 for driving an accelerator, a brake, a steering, a transmission, a vessel ascending and descending hydraulic pressure apparatus and the like, an alarm, and a controlling device 4 connected to them, as shown in FIG. 2. The controller 4 is, for example, constituted by a micro computer and the like, and is further connected to a wireless system with respect to the other unmanned dump trucks B1 to B3, a loading machine B4 and a central monitoring station C. Then, the controlling device 4 is communicated by wireless with the other vehicles B1 to B4 and the central monitoring station C via the wireless system so that the own vehicle B is controlled with a fleet containing the other vehicles B1 to B4. The driving actuator 2 and the alarm 3 are operated by receiving the communication result and the position Pi and the direction Pd of the own vehicle B on the course A from the own vehicle position and direction detecting device 1 on the basis of a previously stored operation program, whereby the own vehicle B is self propelled. Then, the own vehicle B (the other vehicles B1 to B4 also) has the obstacle detecting apparatus 5 described next.

Detailed Description Text (5):
An outgoing device 51 (i.e., a transmitter) and an incoming device 52 (i.e., receiver) of the obstacle detecting apparatus 5 are provided on a front bumper of the own vehicle B, and as shown in FIG. 2, the outgoing device 51 outgoes a medium (i.e., transmits a signal) such as a sound, a light, an electric wave and the like (a laser light Lo in the first embodiment) to a traveling direction (a forward direction) of the own vehicle B. The incoming (i.e., receives) device 52 incomes a laser light Li reflected by the obstacle D existing in an outgoing direction of the laser light Lo. A calculating device 53 is electrically connected to the outgoing device 51 and the incoming device 52, receives the laser light Lo from the outgoing device 51 and the laser light Li in the incoming device 52, calculates a distance E from the own vehicle B to the obstacle D on the basis of a time difference between an outgoing time of the laser light Lo and an incoming time of the laser light Li, and determines an existence

of the obstacle D on the basis of the distance E. Then, the calculating device 53 inputs the determined information to the controlling device 4 and operates the driving actuator 2, thereby reducing a speed of the own vehicle B and suddenly stopping the vehicle so as to prevent the own vehicle B from being in contact with and colliding with the obstacle D. At the same time, the alarm 3 is operated so as to alarm an existence of the own vehicle B to the disallowable manned vehicle entering to the course, the animal and the like. The obstacle detecting apparatus 5 mentioned above further has the following monitoring mechanism 6.

Detailed Description Text (11):
The vehicle stop detecting device 64 detects a vehicle stop time of the own vehicle B and inputs a vehicle stop signal St to the judging device 65. For example, it is sufficient to detect a neutral time of a transmission, an effect time of a parking brake, a stop time of an engine, a 0 time of a measured vehicle speed in the case of the vehicle B having a vehicle speed meter and the like, thereby generating the vehicle stop signal St. In the first embodiment, the vehicle stop detecting device 64 is provided in a transmission T/M so as to detect a neutral time of the transmission T/M and output the vehicle stop signal St.

Detailed Description Text (20):
(Step 32) When the comparative result is "L1.ltoreq.L.ltoreq.L2", a signal S1 corresponding to "an abnormal sign" is input to the controlling device 4. The controlling device 4 operates the brake while loosening, for example, an accelerator among the operating actuator 2, thereby reducing the speed of the own vehicle B. Further, the controlling device 4 transmits the "abnormal sign" to the central monitoring station C by wireless. The central monitoring station C alarms to the operator and plans an early inspection with respect to the obstacle detecting apparatus 5 of the own vehicle B. In this case, since the "abnormal sign" includes not only the obstacle detecting apparatus 5 but also the rotating device 61, the predetermined reflecting device 62 and the rotating angle detecting device 63, the inspection is performed to them.

Detailed Description Text (29):
A seventh embodiment is as follows. In the first embodiment, no attention is paid to a number of the arranged predetermined reflecting devices 62, however, a plurality of predetermined reflecting devices 62 may be arranged in the medium path Lo-Li from the outgoing device 51 to the incoming device 52. For example, in FIG. 5, three predetermined reflecting devices 62, 62 and 62 are arranged in the medium path Lo-Li from the outgoing device 51 to the incoming device 52. When the structure is made in this manner, a distance searching error is cancelled at a degree that the medium path Lo-Li is lengthened, so that it is possible to accurately process the monitoring program of the flow chart in FIG. 4.

Detailed Description Text (47):
The first to fourteenth embodiments mentioned above correspond to the monitoring mechanism applied to the transmitting and receiving type obstacle detecting apparatus for the vehicle. However, contents of each of the fifth embodiment inherent to the transmitting and receiving type for the vehicle and the first to fourth, the sixth and the eighth to fourteenth embodiments except the seventh embodiment which can not obtain a significant effect as the receiving type can be applied as the monitoring mechanism with respect to the receiving type obstacle detecting apparatus for the vehicle.

Detailed Description Text (61):
In this case, in each of the embodiments mentioned above, the rotating device 61 rotatably supports the outgoing device 51 and the incoming device 52 or the image pickup device 52 (this is called tentatively as an A structure). Further, it is possible to perform a normal obstacle detection and monitoring by fixing the outgoing device 51 and the incoming device 52 or the image pickup device 52 to the vehicle body, supporting the outgoing medium path and the incoming medium path or supporting the reflecting body in the incoming medium path by the rotating device 61 in such a manner as to freely control a rotation, and rotating a reflecting mirror by the rotating device 61 (this is called tentatively as a B

Detailed Description Text (62):

structure). However, in view of intending to freely change the medium path by the rotating device 61, the A and B structures are the same at all.

Detailed Description Text (63):
Accordingly, "SUMMARY OF THE INVENTION" mentioned above corresponds to a description of the A structure on terms, that is, the rotating device 61 integrally supporting the outgoing device 51 and the incoming device 52 in a freely rotatable manner (the first to fifth and seventh aspects), and the rotating device 61 rotatably supporting the image pickup device 52 (the eighth to eleventh and thirteenth aspects), however, the first to fifth and seventh aspects include "the rotating device 61 fixing the outgoing device 51 and the incoming device 52 to the vehicle body and rotatably supporting the reflecting body in the outgoing medium path and the incoming medium path", and on the contrary, the eighth to eleventh and thirteenth aspects include "the rotating device 61 fixing the image pickup device 52 to the vehicle body and rotatably supporting the reflecting body in the incoming medium path".

L4: Entry 5 of 7 File: USPT Oct 17, 1978

DOCUMENT-IDENTIFIER: US 4121273 A
TITLE: Cruise control method and apparatus

Detailed Description Text (17):
Preset counter 83 has a clock input which is connected to the output of AND gate 91. AND gate 91 has two inputs, 95 and 96. Input 95 is connected to a low frequency pulse generator which operates low frequency pulses such as, for example, 7.5 hertz. Input 96 is connected to circuitry 29 of FIG. 2 and receives a signal which enables AND gate 91 to pass the low frequency pulses appearing on input 95. These low frequency pulses increment the count stored in preset counter 83 which in turn causes the vehicle to increase speed. Increasing the counts in preset counter 83 at 7.5 hertz can be equivalent to accelerating the vehicle at approximately one and a half miles-per-hour. Preset counter 83 is also connected to an 8-bit latch 86. 8-bit latch 86 stores the eight most significant bits from preset counter 83. The least significant bit is only equivalent to approximately two-tenths of a mile-per-hour and is not significant enough to be carried by 8-bit latch 86. Latch 86 is used to store the counts in preset counter 83 for future reference. When the brakes of the vehicle are applied, the cruise control system is automatically disengaged and, as described hereinabove, preset counter 83 is reset. Thereafter, if it is desired to resume the speed of the vehicle that was preselected prior to application of the brakes all that is necessary is for the driver of the vehicle to energize a resume switch which causes a signal on line 98 to enable AND gate 88 thereby transferring the counts latched in 8-bit latch 86 to the output of the latch so that the counts stored in 8-bit latch 86 can be compared in resume comparator 87 against the counts being accumulated by preset counter 83. When the counts in preset counter 83 reach the same number as the count stored in latch 86 then counts are no longer allowed to enter preset counter 83. During the resume period AND gate 91 is enabled by the proper input on input 96 thereby allowing the counts in preset counter 83 to increase at a low count rate which means that the vehicle is accelerating at approximately one and a half miles-per-hour. Therefore, by enabling gate 91 the counts in preset counter 83 can be increased to allow the vehicle to resume its previously preselected speed or even to allow the presently preselected speed to be increased. When resume comparator 87 indicates that the counts in preset counter 83 are equal to the counts stored in latch 86 AND gate 89 is enabled which causes a flip-flop formed by NOR gates 66 and 67 to be toggled. The purpose of the flip-flop formed by NOR gates 66 and 67 is to prevent resuming a speed which is higher than the speed that was preselected prior to application of the brakes. One of the inputs to AND gate 89 is coupled to line 98 through an inverter 93. 8-bit latch 86 is also connected to an inverter 92 which passes a signal from circuitry 29 of FIG. 2 to latch 86 resetting latch 86 when the cruise control system is first energized.

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L12: Entry 6 of 131 File: USPT Jan 7, 2003

DOCUMENT-IDENTIFIER: US 6505107 B2
TITLE: Vehicle travel control apparatus

Brief Summary Text (2):
The present invention relates to a vehicle travel control apparatus, and more particularly, to a vehicle travel control apparatus suitable to control a distance between vehicles and a vehicle speed.

Brief Summary Text (4):
Conventional vehicle travel control apparatuses measure, for example, a distance between a one' vehicle and a vehicle traveling ahead and control a degree of opening of a throttle valve or a brake so that the distance between the vehicles is kept constant in accordance with the vehicle speed of the one's own vehicle. Further, the vehicle travel control apparatuses control a degree of opening of the throttle valve or the brake so that the one's own vehicle keeps a constant vehicle speed.

Brief Summary Text (6):
However, it has become apparent that when a vehicle was actually traveled on a road using the conventional vehicle travel control apparatuses, the control performance of the apparatuses were lowered depending upon a state of the road. For example, when a road was curved or began to ascend, the conventional vehicle travel control apparatuses started to control a distance between vehicles and a vehicle speed after they detected a change of state of the road based on a change of a vehicle speed, and the like, which caused a time lag until a proper control was actually executed because the start of control was delayed. As a result, it has become apparent that a problem arose in that the conventional vehicle travel control apparatuses could not smoothly control a vehicle. For example, when a vehicle comes to an upward slope, the speed of the vehicle is reduced and the apparatuses increase the speed of the vehicle after they detect the reduction of the speed, which sometimes makes it difficult to keep the vehicle at a constant speed. In particular, as the slope of a road is ~~more steep, a~~ response is more delayed. Further, while a vehicle must reduce a speed when it makes a turn, a time lag is caused until the speed is actually reduced.

Brief Summary Text (7):
To cope with the above problems, the inventors examined a system for improving the controllability of a vehicle control apparatus by predicting a change of state of a road making use of data of curves and slopes stored in position information displays which are typically a car navigator. For this purpose, the inventors examined a system for associating a position information display with a vehicle control apparatus and for sharing the information of the respective apparatuses. When the information of the plurality of apparatuses having a different function was shared, the inventors examined a system for simultaneously sharing the information using serial communication to reduce the number of communication lines that connect the plurality of apparatuses.

Brief Summary Text (10):
(1) To achieve the above object, the present invention includes a plurality of operating systems, an OS switching means for switching the plurality of operating systems, and a shared object (CO) having a memory resource which can be referred to from the plurality of operating systems, wherein the shared object (CO) shares at least road information, and the road information registered by the application of one of the operating systems can be referred to from the application of the other

operating system.

Brief Summary Text (12):
(2) In the above (1), it is preferable that while one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) prohibits the other operating system from register road information to the shared object or from referring to the road information.

Brief Summary Text (13):
With this constitution, reference to incorrect information can be prevented when road information is registered to the shared object or referred to from the other operating system.

Brief Summary Text (14):
(3) In the above (1), it is preferable that when one of the operating systems registers road information to the shared object or refers to the road information, the shared object notifies the other operating system that road information is registered to the shared object or the road information is referred to.

Brief Summary Text (15):
With this constitution, the application of the other operating system can recognize that road information has been renewed.

Brief Summary Text (16):
(4) In the above (1), it is preferable that the application of one of the operating systems analyzes a signal received through broadcasting or communication and extracts road information as well as registers road information to the shared object, and the application of the other operating system controls the traveling speed of a one' own vehicle referring to the road information registered to the shared object.

Brief Summary Text (17):
(5) In the above (4), it is preferable that the application of one of the operating systems analyzes the signal received through the broadcasting or the communication and extracts information added to the road information as well as registers the added information to the shared object, and the application of the other operating system controls the traveling speed of the one's own vehicle referring to the road information and the added information registered to the shared object and to the traveling environment information of the vicinity of the one's own vehicle.

Brief Summary Text (18):
(6) Further, to achieve the above object, the present invention includes a plurality of operating systems (OS1, OS2) and a shared object (CO) having a memory resource which can be referred to from the plurality of operating systems, wherein the shared object (CO) shares at least road information, and the road information registered by the application of one of the operating systems can be referred to from the application of the other operating system.

Brief Summary Text (19):
(7) In the above (6), it is preferable that while one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) prohibits the other operating system from register road information to the shared object or from referring to the road information.

Brief Summary Text (20):
(8) In the above (6), it is preferable that when one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) notifies the other operating system that road information is registered to the shared object or the road information is referred to.

Brief Summary Text (21):
(9) In the above (6), it is preferable that the application of one of the operating systems analyzes a signal received through broadcasting or communication and extracts road information as well as registers road information to the shared object, and the application of the other operating system controls the traveling speed of a one' own vehicle referring to the road information registered to the shared object.

Brief Summary Text (22):
(10) In the above (9), it is preferable that the application of one of the operating systems analyzes the signal received through the broadcasting or the communication and extracts information added to the road information as well as registers the added information to the shared object, and the application of the other operating system controls the traveling speed of the one's own vehicle referring to the road information and the added information registered to the shared object and to the traveling environment information of the vicinity of the one's own vehicle.

Detailed Description Text (7):
The vehicle speed controller SC includes a wheel speed sensor and detects the speed of the one's own vehicle as described later using FIG. 2. Further, the vehicle speed controller SC captures a target distance between vehicles set by the operation of a driver using a target-distance-between-vehicles setting means SET. The vehicle speed controller SC includes a position information display means like a car navigator as described later using FIG. 2 and shares road information such as curved roads, slopes, and the like with the position information display means.

Detailed Description Text (8):
The vehicle speed controller SC calculates a target speed based on the distance between vehicles and the relative speed which are transmitted from the radar sensor RS, the one's own vehicle speed detected by the wheel speed sensor, the target distance between vehicles set by the setting means SET and the road information shared by the controller SC and the position information display means. Further, the vehicle speed controller SC calculates target torque based on the calculated target speed and the one's own vehicle speed and transmits a target torque command to the engine controller EC and the brake controller BC. Further, the vehicle speed controller SC transmits a gear change command to the transmission controller TC when it is necessary to change a gear ratio.

Detailed Description Text (14):
The vehicle speed controller SC according to the embodiment includes at least two functions of a position information display means such as car navigator and a vehicle control means for controlling a distance between vehicles, and has operating systems (OS) installed thereon corresponding to the respective functions. Note that while the vehicle speed controller SC includes OSs other than the two OSs, at least the OS of the position information display means and the OS of the vehicle speed control means share position information such as road information and the like.

Detailed Description Text (16):
The arithmetic processing unit 100 detects a present position from the sensor information outputted from various sensors (a wheel speed sensor 150, a direction sensor 155, a gyro 160, a GPS receiver 165) for measuring a position. Then, the arithmetic processing unit 100 reads map mesh data necessary to display a map from a map database 125 based on the obtained present position information and graphically expands the map data. The present position is displayed on a display 120 by overlapping a mark indicating the present position on the map data. Further, the arithmetic processing unit 100 searches an optimum path connecting a destination instructed by a user to the present position and displays the path on the display 120 by overlapping it on a map so as to guide the user to the destination through the path. Furthermore, the arithmetic processing unit 100 inquires about dynamic information necessary to the user to an information service center and displays the obtained dynamic information on the display 120. As described above, the arithmetic processing unit 100 has a function as a position information display means like a car navigation and includes a first OS for achieving this function as described later using FIG. 4.

Detailed Description Text (17):
Further, the arithmetic processing unit 100 calculates the target speed based on the distance between vehicles and the relative speed transmitted from the radar sensor RS, the one's own vehicle speed detected by the wheel speed sensor, the target distance between vehicles set by the setting means SET and the road information shared by the vehicle speed controller SC and the position information display means. Then, the vehicle speed controller SC calculates the target torque based on the calculated

target speed and the one's own vehicle speed and transmits the target torque command to the engine controller EC and the brake controller BC, respectively. Further, the vehicle speed controller SC transmits the gear change command to the transmission controller TC when it is necessary to change the gear ratio. As described above, the arithmetic processing unit 100 includes a function as a vehicle speed control means and has the second OS for achieving the function as described later using FIG. 4.

Detailed Description Text (18):
The input/output control unit 110 is a unit for connecting the arithmetic processing unit 100 to peripheral devices and includes an I/O corresponding to the interface of the peripheral devices. The input/output control unit 110 will be described below in detail using FIG. 3. The input/output control unit 110 includes the display 120, the map database 125, an audio input/output unit 130, an input unit 135, a LAN unit 140, a communication unit 145, the wheel speed sensor 150, the direction sensor 155, the gyro 160, the GPS receiver 165, and a broadcast receiver 170 which are connected thereto.

Detailed Description Text (20):
The communication unit 145 is a unit for executing bi-directional communication by being connected to a public network and to a dedicated network, a portable phone and a PHS are available as equipment to be connected to the public network and an MCA system is available as the dedicated network. Further, A DSRC (short distance spot communication) such as an ETC (electronic tall collection) the installation of which is underway to collect a toll and a traffic tax is also included in the communication unit 145. Latest contents can be captured into a vehicle in abundance by connecting a vehicle-mounted navigation means to the Internet through the communication unit 145. Available as an example of the contents is map information including map mesh data, guide information, searched information and the gradients and radii of curvature of roads and the positions of intersections within the radius of 2 km from the location where the one's own vehicle exists.

Detailed Description Text (22):
The map database 125 is composed of a large capacity storage medium such as a CD-ROM, DVD-ROM, DVD-RAM, IC card, hard disc and the like. The map database stores the map mesh data, guide information, searched information and the like which are necessary to display a map. Further, the map database 125 records map mesh data, guide information, and searched information as well as the gradients and radii of curvature of roads, the distance to a target position and the like which are necessary to control a vehicle through the communication unit 145 and the broadcast receiver 170 or stores them by updating them when necessary.

Detailed Description Text (23):
The audio input/output unit 130 converts a message to the user (for example, a guide voice), which is created by the arithmetic processing unit 100 to guide a vehicle along a guide path, into an audio signal. Further, the audio input/output unit 130 recognizes the voice of the user and transmits a result of recognition to the arithmetic processing unit 100. It should be noted that the audio input/output unit 130 may only include a function for converting the audio signal into a digital signal, and a voice may be recognized by the arithmetic processing unit 100.

Detailed Description Text (26):
A sensor used to detect a position by the vehicle-mounted navigation means is composed of the wheel speed sensor 150, the direction sensor 155, the gyro 160, the GPS receiver 165, and the like, wherein the wheel speed sensor 150 measures a distance from the product of the circumference of a wheel and the measured number of revolution of the wheel and further measures an angle at which a moving body turns from the difference between the numbers of revolution of a pair of wheels, the direction sensor 155 detects an direction toward which the moving body looks by detecting the magnet field of the earth, the gyro 160 detects an angle at which the moving body such as an optical fiber gyro, a vibration gyro and the like turns, and the GPS receiver 165 measures a present position, a moving speed, and a moving direction of the moving body by receiving signals from at least three GPS satellites and by measuring distances between the moving body and the GPS satellites and ratios of change of the distances. Note that all the sensors are not essential to the detection of the position, and the respective sensors may be used individually or in combination.

Detailed Description Text (47):
In the vehicle speed controller SC, the information managed by the shared object CO includes position information to be managed by a node unit, for example, a present position of the one's own vehicle, a destination, an area through which the vehicle travels, position information to be managed by a link unit such as traffic jam information and a path information up to a predetermined location, position information and static information and dynamic information added to the position information, and peripheral information of the one's own vehicle such as a distance between vehicles, a relative speed, and a one's own vehicle speed. The static information is information that is not changed by time such as the name of a facility, contents of service provided by the facility, and the like. The dynamic information is information that is changed as a time passes such as a business hour, the full and vacant information of a parking, and the like. Note that information registered to the shard object is not limited to the above information and it is possible to register various types of information to the shared object and to refer to the various types of information therefrom.

Detailed Description Text (91):
First, a relationship between a hardware constitution and a software constitution of the vehicle speed controller SC according to the embodiment when a vehicle speed control application and a navigation application are installed on the vehicle control apparatus according to the embodiment will be described using FIG. 9.

Detailed Description Text (93):
In the embodiment, a vehicle speed control application SCA is installed as an application of the first operating system OS1. Further, a navi-application NA is installed as an application of the second operating system OS2. The first operating system OS1 is a real time operating system arranged simply in order to reliably control traveling at a high speed. The second operating system OS2 is a real time operating system for executing an application which requests complex real time processing such as car navigation although the processing is executed at a low speed.

Detailed Description Text (94):
A navi-basic function SCA-P is a library having a basic function necessary to a navigation apparatus. The navi-basic function SCA-P includes a map display function, a search function, a one's own vehicle position measuring function, a recommended path search function, a recommended path guide function, and the like. The navi-application NA analyzes position information and user operation information and invokes the navi-basic function SCA-P, thereby providing a user with navi-information through an output interface such as a display, a voice, and the like. A road information manager NA-R registers road information to the shared object CO as well as refers to the road information from the shared object CO. Exemplified as the information registered to the shared object CO are road information such as the gradient and the radius of curvature of a road at a position where a vehicle exists, and the like, the position information of facilities and the static/dynamic information added to the position information, and supplementary information such as traffic jam information, recommended path information, and the like. A method of expressing the traffic jam information and the recommended path information includes various methods such as a method of expressing them by enumerating dots and columns showing position information, a method of expressing them by links of curved lines, and the like.

Detailed Description Text (95):
A road information handler SCA-R refers the road information registered by the road information manager NA-R as well as registers necessary information to the shared object CO. The speed control basic function SCA-P sets a target speed from a distance between vehicles, a relative speed and a one's own vehicle speed. At that time, a speed control basic function SCA-S also sets the target speed based on the road information referred to from the shared object CO by the road information handler SCA-R. Then, the speed control basic function SCA-S calculates target engine torque and target brake torque based on the target speed.

Detailed Description Text (102):
Next, at step s420, the speed control basic function SCA-S sets a target speed on straight road Vtmp. The target speed on straight road Vtmp is set by calculating the following formula (1).

Detailed Description Text (104):
Next, at step s425, the road information handler SCA-R acquires road information from the inter-OS shared memory CM of a shared object COb. Then, the speed control basic function SCA-S calculates the radius of curvature of a road on which a vehicle intends to travel from the acquired road information. Since the road information is represented by the coordinates of respective points (nodes) on a road (coordinates of latitudes and longitudes), the radius of curvature of the road can be obtained by connecting these nodes. Further, since the road information includes heights above sea level, in addition to the coordinates of the respective points (nodes) on the road, the gradients of the road can be determined by continuously connecting these nodes.

Detailed Description Text (105):
Next, at step s430, the speed control basic function SCA-S determines the target speed Vcmd from the following formula (2) using a corrected speed Vcoast determined from the radius or curvature r. The corrected speed Vcoast is a correction component of a speed to reduce the speed in accordance with a radius of curvature of a road.

Detailed Description Text (119):
While the traveling speed is controlled based on the information of the radius of curvature of the road information in the above explanation, the traveling speed may be controlled based on other road information. That is, as described above, the road information manager NA-R registers the road information to the shared object CO as well as refers to the road information from the shared object CO. Exemplified as the information registered to the shared object CO are road information such as the gradient and the radius of curvature of a road at a position where a vehicle exists, and the like, the position information of facilities and the static/dynamic information added to the position information, and supplementary information such as traffic jam information, recommended path information, and the like. The vehicle speed control application SCA can also control the traveling speed of the one's own vehicle referring to, for example, a gradient of the road information registered to the shared object CO.

Detailed Description Text (120):
Further, the navi-application NA analyzes a signal received through broadcasting or communication by means of the broadcast receiver 170 or the GPS receiver 160 and extracts road information as well as information added to the road information and registers the added information to the shared object CO. The vehicle speed control application SCA can control the traveling speed of the one's own vehicle based on the road information and the added information registered to the shared object CO. Further, the traveling speed of the one's own vehicle can also be controlled referring to the traveling environment information of the vicinity of the one's own vehicle registered to the shared object CO by the navi-application NA.

Detailed Description Text (121):
Further, while the combination of the ACC (vehicle speed control) and the car navigation has been described in the above description, the present invention can be applied to any combination of controls other than these two controls. For example, the present invention can be applied to a combination of at least two of 1) engine control (fuel control, throttle control and the like, ignition timing control, EGR control, and the like), 2) radar control (frequency control, FFT, tracking processing, and the like), 3) ACC control (vehicle speed control), 4) brake control (brake fluid pressure control), 5) AT control (solenoid ON/OFF, line pressure, gear ratio, and the like), 6) car navigation, 7) steering control (current, hydraulic pressure, steering torque, and the like), and 8) camera control (focal length, diaphragm, quantity of light, wavelength and the like).

Detailed Description Text (122):
As described above, this embodiment can provide the vehicle travel control apparatus which can realize the functions of a plurality of apparatuses only by itself, can set a vehicle speed based on road information without setting a communication task for sharing information and can provide a high grade drive support with a driver.

Detailed Description Text (123):
Further, the use of the shared object in the position information display device in

which the plurality of operating systems operate on the singe processor permits the applications installed on the respective operating systems to asynchronously register road information and to asynchronously refer to the road information. Accordingly, applications which operate in association with each other using the road information between different operating systems can be easily developed. The introduction of the shared object can realize these functions, by which an easy-to-operate user interface can be provided.

Detailed Description Text (124):
Further, when road information is registered to or modified in the shared object from the application of one of the operating systems, the application of the other operating system is prohibited from registering road information to the shared object or from referring to the road information, which improves the reliability of the system by avoiding the reference to erroneous position information.

Detailed Description Text (125):
Then, when the road information is registered to or modified in the shared object from the application of the one of the operating systems, a message for notifying the registration and the reference of the road information is transmitted to the applications which operate on the plurality of operating systems, which improves the real time property that the road information can be instantly referred to in synchronism with the message as well as the above processing can be carried out with a minimum load on the processor.

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L12: Entry 23 of 131 File: USPT Apr 30, 2002

DOCUMENT-IDENTIFIER: US 6381524 B1
TITLE: Vehicle travel control apparatus

Abstract Text (1):
An object of the present invention is to provide a vehicle control apparatus which makes it possible to share information by a plurality of devices and which can improve controllability. An OS switching means (OS-CH) switches a plurality of operating system (OS1, OS2). A shared object (CO) has a memory resource which can be referred to from the plurality of operating systems. The shared object (CO) shares at least road information, and the road information registered by the application of one of the operating systems can be referred to from the application of the other operating system.

Brief Summary Text (2):
The present invention relates to a vehicle travel control apparatus, and more particularly, to a vehicle travel control apparatus suitable to control a distance between vehicles and a vehicle speed.

Brief Summary Text (4):
Conventional vehicle travel control apparatuses measure, for example, a distance between a one' vehicle and a vehicle traveling ahead and control a degree of opening of a throttle valve or a brake so that the distance between the vehicles is kept constant in accordance with the vehicle speed of the one's own vehicle. Further, the vehicle travel control apparatuses control a degree of opening of the throttle valve or the brake so that the one's own vehicle keeps a constant vehicle speed.

Brief Summary Text (6):
However, it has become apparent that when a vehicle was actually traveled on a road using the conventional vehicle travel control apparatuses, the control performance of the apparatuses were lowered depending upon a state of the road. For example, when a road was curved or began to ascend, the conventional vehicle travel control apparatuses started to control a distance between vehicles and a vehicle speed after they detected a change of state of the road based on a change of a vehicle speed, and the like, which caused a time lag until a proper control was actually executed because the start of control was delayed. As a result, it has become apparent that a problem arose in that the conventional vehicle travel control apparatuses could not smoothly control a vehicle. For example, when a vehicle comes to an upward slope, the speed of the vehicle is reduced and the apparatuses increase the speed of the vehicle after they detect the reduction of the speed, which sometimes makes it difficult to keep the vehicle at a constant speed. In particular, as the slope of a road is more steep, a response is more delayed. Further, while a vehicle must reduce a speed when it makes a turn, a time lag is caused until the speed is actually reduced.

Brief Summary Text (7):
To cope with the above problems, the inventors examined a system for improving the controllability of a vehicle control apparatus by predicting a change of state of a road making use of data of curves and slopes stored in position information displays which are typically a car navigator. For this purpose, the inventors examined a system for associating a position information display with a vehicle control apparatus and for sharing the information of the respective apparatuses. When the information of the plurality of apparatuses having a different function was shared, the inventors examined a system for simultaneously sharing the information using serial

communication to reduce the number of communication lines that connect the plurality of apparatuses.

Brief Summary Text (10):
(1) To achieve the above object, the present invention includes a plurality of operating systems, an OS switching means for switching the plurality of operating systems, and a shared object (CO) having a memory resource which can be referred to from the plurality of operating systems, wherein the shared object (CO) shares at least road information, and the road information registered by the application of one of the operating systems can be referred to from the application of the other operating system.

Brief Summary Text (12):
(2) In the above (1), it is preferable that while one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) prohibits the other operating system from register road information to the shared object or from referring to the road information.

Brief Summary Text (13):
With this constitution, reference to incorrect information can be prevented when road information is registered to the shared object or referred to from the other operating system.

Brief Summary Text (14):
(3) In the above (1), it is preferable that when one of the operating systems registers road information to the shared object or refers to the road information, the shared object notifies the other operating system that road information is registered to the shared object or the road information is referred to.

Brief Summary Text (15):
With this constitution, the application of the other operating system can recognize that road information has been renewed.

Brief Summary Text (16):
(4) In the above (1), it is preferable that the application of one of the operating systems analyzes a signal received through broadcasting or communication and extracts road information as well as registers road information to the shared object, and the application of the other operating system controls the traveling speed of a one' own vehicle referring to the road information registered to the shared object.

Brief Summary Text (17):
(5) In the above (4), it is preferable that the application of one of the operating systems analyzes the signal received through the broadcasting or the communication and extracts information added to the road information as well as registers the added information to the shared object, and the application of the other operating system controls the traveling speed of the one's own vehicle referring to the road information and the added information registered to the shared object and to the traveling environment information of the vicinity of the one's own vehicle.

Brief Summary Text (18):
(6) Further, to achieve the above object, the present invention includes a plurality of operating systems (OS1, OS2) and a shared object (CO) having a memory resource which can be referred to from the plurality of operating systems, wherein the shared object (CO) shares at least road information, and the road information registered by the application of one of the operating systems can be referred to from the application of the other operating system.

Brief Summary Text (19):
(7) In the above (6), it is preferable that while one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) prohibits the other operating system from register road information to the shared object or from referring to the road information.

Brief Summary Text (20):
(8) In the above (6), it is preferable that when one of the operating systems

registers road information to the shared object or refers to the road information, the shared object (CO) notifies the other operating system that road information is registered to the shared object or the road information is referred to.

Brief Summary Text (21):
(9) In the above (6), it is preferable that the application of one of the operating systems analyzes a signal received through broadcasting or communication and extracts road information as well as registers road information to the shared object, and the application of the other operating system controls the traveling speed of a one' own vehicle referring to the road information registered to the shared object.

Brief Summary Text (22):
(10) In the above (9), it is preferable that the application of one of the operating systems analyzes the signal received through the broadcasting or the communication and extracts information added to the road information as well as registers the added information to the shared object, and the application of the other operating system controls the traveling speed of the one's own vehicle referring to the road information and the added information registered to the shared object and to the traveling environment information of the vicinity of the one's own vehicle.

Detailed Description Text (7):
The vehicle speed controller SC includes a wheel speed sensor and detects the speed of the one's own vehicle as described later using FIG. 2. Further, the vehicle speed controller SC captures a target distance between vehicles set by the operation of a driver using a target-distance-between-vehicles setting means SET. The vehicle speed controller SC includes a position information display means like a car navigator as described later using FIG. 2 and shares road information such as curved roads, slopes, and the like with the position information display means.

Detailed Description Text (8):
The vehicle speed controller SC calculates a target speed based on the distance between vehicles and the relative speed which are transmitted from the radar sensor RS, the one's own vehicle speed detected by the wheel speed sensor, the target distance between vehicles set by the setting means SET and the road information shared by the controller SC and the position information display means. Further, the vehicle speed controller SC calculates target torque based on the calculated target speed and the one's own vehicle speed and transmits a target torque command to the engine controller EC and the brake controller BC. Further, the vehicle speed controller SC transmits a gear change command to the transmission controller TC when it is necessary to change a gear ratio.

Detailed Description Text (14):
The vehicle speed controller SC according to the embodiment includes at least two functions of a position information display means such as car navigator and a vehicle control means for controlling a distance between vehicles, and has operating systems (OS) installed thereon corresponding to the respective functions. Note that while the vehicle speed controller SC includes OSs other than the two OSs, at least the OS of the position information display means and the OS of the vehicle speed control means share position information such as road information and the like.

Detailed Description Text (16):
The arithmetic processing unit 100 detects a present position from the sensor information outputted from various sensors (a wheel speed sensor 150, a direction sensor 155, a gyro 160, a GPS receiver 165) for measuring a position. Then, the arithmetic processing unit 100 reads map mesh data necessary to display a map from a map database 125 based on the obtained present position information and graphically expands the map data. The present position is displayed on a display 120 by overlapping a mark indicating the present position on the map data. Further, the arithmetic processing unit 100 searches an optimum path connecting a destination instructed by a user to the present position and displays the path on the display 120 by overlapping it on a map so as to guide the user to the destination through the path. Furthermore, the arithmetic processing unit 100 inquires about dynamic information necessary to the user to an information service center and displays the obtained dynamic information on the display 120. As described above, the arithmetic processing unit 100 has a function as a position information display means like a car

navigation and includes a first OS for achieving this function as described later using FIG. 4.

Detailed Description Text (17):
Further, the arithmetic processing unit 100 calculates the target speed based on the distance between vehicles and the relative speed transmitted from the radar sensor RS, the one's own vehicle speed detected by the wheel speed sensor, the target distance between vehicles set by the setting means SET and the road information shared by the vehicle speed controller SC and the position information display means. Then, the vehicle speed controller SC calculates the target torque based on the calculated target speed and the one's own vehicle speed and transmits the target torque command to the engine controller EC and the brake controller BC, respectively. Further, the vehicle speed controller SC transmits the gear change command to the transmission controller TC when it is necessary to change the gear ratio. As described above, the arithmetic processing unit 100 includes a function as a vehicle speed control means and has the second OS for achieving the function as described later using FIG. 4.

Detailed Description Text (18):
The input/output control unit 110 is a unit for connecting the arithmetic processing unit 100 to peripheral devices and includes an I/O corresponding to the interface of the peripheral devices. The input/output control unit 110 will be described below in detail using FIG. 3. The input/output control unit 110 includes the display 120, the map database 125, an audio input/output unit 130, an input unit 135, a LAN unit 140, a communication unit 145, the wheel speed sensor 150, the direction sensor 155, the gyro 160, the GPS receiver 165, and a broadcast receiver 170 which are connected thereto.

Detailed Description Text (20):
The communication unit 145 is a unit for executing bi-directional communication by being connected to a public network and to a dedicated network, a portable phone and a PHS are available as equipment to be connected to the public network and an MCA system is available as the dedicated network. Further, A DSRC (short distance spot communication) such as an ETC (electronic tall collection) the installation of which is underway to collect a toll and a traffic tax is also included in the communication unit 145. Latest contents can be captured into a vehicle in abundance by connecting a vehicle-mounted navigation means to the Internet through the communication unit 145. Available as an example of the contents is map information including map mesh data, guide information, searched information and the gradients and radii of curvature of roads and the positions of intersections within the radius of 2 km from the location where the one's own vehicle exists.

Detailed Description Text (22):
The map database 125 is composed of a large capacity storage medium such as a CD-ROM, DVD-ROM, DVD-RAM, IC card, hard disc and the like. The map database stores the map mesh data, guide information, searched information and the like which are necessary to display a map. Further, the map database 125 records map mesh data, guide information, and searched information as well as the gradients and radii of curvature of roads, the distance to a target position and the like which are necessary to control a vehicle through the communication unit 145 and the broadcast receiver 170 or stores them by updating them when necessary.

Detailed Description Text (23):
The audio input/output unit 130 converts a message to the user (for example, a guide voice), which is created by the arithmetic processing unit 100 to guide a vehicle along a guide path, into an audio signal. Further, the audio input/output unit 130 recognizes the voice of the user and transmits a result of recognition to the arithmetic processing unit 100. It should be noted that the audio input/output unit 130 may only include a function for converting the audio signal into a digital signal, and a voice may be recognized by the arithmetic processing unit 100.

Detailed Description Text (26):
A sensor used to detect a position by the vehicle-mounted navigation means is composed of the wheel speed sensor 150, the direction sensor 155, the gyro 160, the GPS receiver 165, and the like, wherein the wheel speed sensor 150 measures a distance from the product of the circumference of a wheel and the measured number of revolution of the wheel and further measures an angle at which a moving body turns from the

difference between the numbers of revolution of a pair of wheels, the direction sensor 155 detects an direction toward which the moving body looks by detecting the magnet field of the earth, the gyro 160 detects an angle at which the moving body such as an optical fiber gyro, a vibration gyro and the like turns, and the GPS receiver 165 measures a present position, a moving speed, and a moving direction of the moving body by receiving signals from at least three GPS satellites and by measuring distances between the moving body and the GPS satellites and ratios of change of the distances. Note that all the sensors are not essential to the detection of the position, and the respective sensors may be used individually or in combination.

Detailed Description Text (47):
In the vehicle speed controller SC, the information managed by the shared object CO includes position information to be managed by a node unit, for example, a present position of the one's own vehicle, a destination, an area through which the vehicle travels, position information to be managed by a link unit such as traffic jam information and a path information up to a predetermined location, position information and static information and dynamic information added to the position information, and peripheral information of the one's own vehicle such as a distance between vehicles, a relative speed, and a one's own vehicle speed. The static information is information that is not changed by time such as the name of a facility, contents of service provided by the facility, and the like. The dynamic information is information that is changed as a time passes such as a business hour, the full and vacant information of a parking, and the like. Note that information registered to the shard object is not limited to the above information and it is possible to register various types of information to the shared object and to refer to the various types of information therefrom.

Detailed Description Text (91):
First, a relationship between a hardware constitution and a software constitution of the vehicle speed controller SC according to the embodiment when a vehicle speed control application and a navigation application are installed on the vehicle control apparatus according to the embodiment will be described using FIG. 9.

Detailed Description Text (93):
In the embodiment, a vehicle speed control application SCA is installed as an application of the first operating system OS1. Further, a navi-application NA is installed as an application of the second operating system OS2. The first operating system OS1 is a real time operating system arranged simply in order to reliably control traveling at a high speed. The second operating system OS2 is a real time operating system for executing an application which requests complex real time processing such as car navigation although the processing is executed at a low speed.

Detailed Description Text (94):
A navi-basic function SCA-P is a library having a basic function necessary to a navigation apparatus. The navi-basic function SCA-P includes a map display function, a search function, a one's own vehicle position measuring function, a recommended path search function, a recommended path guide function, and the like. The navi-application NA analyzes position information and user operation information and invokes the navi-basic function SCA-P, thereby providing a user with navi-information through an output interface such as a display, a voice, and the like. A road information manager NA-R registers road information to the shared object CO as well as refers to the road information from the shared object CO. Exemplified as the information registered to the shared object CO are road information such as the gradient and the radius of curvature of a road at a position where a vehicle exists, and the like, the position information of facilities and the static/dynamic information added to the position information, and supplementary information such as traffic jam information, recommended path information, and the like. A method of expressing the traffic jam information and the recommended path information includes various methods such as a method of expressing them by enumerating dots and columns showing position information, a method of expressing them by links of curved lines, and the like.

Detailed Description Text (95):
A road information handler SCA-R refers the road information registered by the road information manager NA-R as well as registers necessary information to the shared object CO. The speed control basic function SCA-P sets a target speed from a distance

between vehicles, a relative speed and a one's own vehicle speed. At that time, a speed control basic function SCA-S also sets the target speed based on the road information referred to from the shared object CO by the road information handler SCA-R. Then, the speed control basic function SCA-S calculates target engine torque and target brake torque based on the target speed.

Detailed Description Text (102):
Next, at step s420, the speed control basic function SCA-S sets a target speed on straight road Vtmp. The target speed on straight road Vtmp is set by calculating the following formula (1).

Detailed Description Text (104):
Next, at step s425, the road information handler SCA-R acquires road information from the inter-OS shared memory CM of a shared object COb. Then, the speed control basic function SCA-S calculates the radius of curvature of a road on which a vehicle intends to travel from the acquired road information. Since the road information is represented by the coordinates of respective points (nodes) on a road (coordinates of latitudes and longitudes), the radius of curvature of the road can be obtained by connecting these nodes. Further, since the road information includes heights above sea level, in addition to the coordinates of the respective points (nodes) on the road, the gradients of the road can be determined by continuously connecting these nodes.

Detailed Description Text (105):
Next, at step s430, the speed control basic function SCA-S determines the target speed Vcmd from the following formula (2) using a corrected speed Vcoast determined from the radius or curvature r. The corrected speed Vcoast is a correction component of a speed to reduce the speed in accordance with a radius of curvature of a road.

Detailed Description Text (119):
While the traveling speed is controlled based on the information of the radius of curvature of the road information in the above explanation, the traveling speed may be controlled based on other road information. That is, as described above, the road information manager NA-R registers the road information to the shared object CO as well as refers to the road information from the shared object CO. Exemplified as the information registered to the shared object CO are road information such as the gradient and the radius of curvature of a road at a position where a vehicle exists, and the like, the position information of facilities and the static/dynamic information added to the position information, and supplementary information such as traffic jam information, recommended path information, and the like. The vehicle speed control application SCA can also control the traveling speed of the one's own vehicle referring to, for example, a gradient of the road information registered to the shared object CO.

Detailed Description Text (120):
Further, the navi-application NA analyzes a signal received through broadcasting or communication by means of the broadcast receiver 170 or the GPS receiver 160 and extracts road information as well as information added to the road information and registers the added information to the shared object CO. The vehicle speed control application SCA can control the traveling speed of the one's own vehicle based on the road information and the added information registered to the shared object CO. Further, the traveling speed of the one's own vehicle can also be controlled referring to the traveling environment information of the vicinity of the one's own vehicle registered to the shared object CO by the navi-application NA.

Detailed Description Text (121):
Further, while the combination of the ACC (vehicle speed control) and the car navigation has been described in the above description, the present invention can be applied to any combination of controls other than these two controls. For example, the present invention can be applied to a combination of at least two of 1) engine control (fuel control, throttle control and the like, ignition timing control, EGR control, and the like), 2) radar control (frequency control, FFT, tracking processing, and the like), 3) ACC control (vehicle speed control), 4) brake control (brake fluid pressure control), 5) AT control (solenoid ON/OFF, line pressure, gear ratio, and the like), 6) car navigation, 7) steering control (current, hydraulic pressure, steering torque, and the like), and 8) camera control (focal length, diaphragm, quantity of light,

wavelength and the like)..

Detailed Description Text (122):
As described above, this embodiment can provide the vehicle travel control apparatus which can realize the functions of a plurality of apparatuses only by itself, can set a vehicle speed based on road information without setting a communication task for sharing information and can provide a high grade drive support with a driver.

Detailed Description Text (123):
Further, the use of the shared object in the position information display device in which the plurality of operating systems operate on the singe processor permits the applications installed on the respective operating systems to asynchronously register road information and to asynchronously refer to the road information. Accordingly, applications which operate in association with each other using the road information between different operating systems can be easily developed. The introduction of the shared object can realize these functions, by which an easy-to-operate user interface can be provided.

Detailed Description Text (124):
Further, when road information is registered to or modified in the shared object from the application of one of the operating systems, the application of the other operating system is prohibited from registering road information to the shared object or from referring to the road information, which improves the reliability of the system by avoiding the reference to erroneous position information.

Detailed Description Text (125):
Then, when the road information is registered to or modified in the shared object from the application of the one of the operating systems, a message for notifying the registration and the reference of the road information is transmitted to the applications which operate on the plurality of operating systems, which improves the real time property that the road information can be instantly referred to in synchronism with the message as well as the above processing can be carried out with a minimum load on the processor.

CLAIMS:

1. A vehicle travel control apparatus, characterized by comprising:

a plurality of operating systems (OS1, OS2);

an OS switching means (OS-CH) for switching the plurality of operating systems; and

a shared object (CO) having a memory resource which can be referred to from the plurality of operating systems, wherein the shared object (CO) shares at least road information, and the road information registered by the application of one of the operating systems can be referred to from the application of the other operating system.

2. A vehicle travel control apparatus according to claim 1, wherein while one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) prohibits the other operating system from register road information to the shared object or from referring to the road information.

3. A vehicle travel control apparatus according to claim 1, wherein when one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) notifies the other operating system that road information is registered to the shared object or the road information is referred to.

4. A vehicle travel control apparatus according to claim 1, wherein the application of one of the operating systems analyzes a signal received through broadcasting or communication and extracts road information as well as registers road information to the shared object, and the application of the other operating system controls the traveling speed of a one's own vehicle referring to the road information registered to

the shared object.

5. A vehicle travel control apparatus according to claim 4, wherein the application of one of the operating systems analyzes the signal received through the broadcasting or the communication and extracts information added to the road information as well as registers the added information to the shared object, and the application of the other operating system controls the traveling speed of the one's own vehicle referring to the road information and the added information registered to the shared object and to the traveling environment information of the vicinity of the one's own vehicle.

6. A vehicle travel control apparatus, characterized by comprising:

a plurality of operating systems (OS1, OS2); and

a shared object (CO) having a memory resource which can be referred to from the plurality of operating systems, wherein the shared object (CO) shares at least road information, and the road information registered by the application of one of the operating systems can be referred to from the application of the other operating system.

7. A vehicle travel control apparatus according to claim 6, wherein while one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) prohibits the other operating system from register road information to the shared object or from referring to the road information.

8. A vehicle travel control apparatus according to claim 6, wherein when one of the operating systems registers road information to the shared object or refers to the road information, the shared object (CO) notifies the other operating system that road information is registered to the shared object or the road information is referred to.

9. A vehicle travel control apparatus according to claim 6, wherein the application of one of the operating systems analyzes a signal received through broadcasting or communication and extracts road information as well as registers road information to the shared object, and the application of the other operating system controls the traveling speed of a one' own vehicle referring to the road information registered to the shared object.

10. A vehicle travel control apparatus according to claim 9, wherein the application of one of the operating systems analyzes the signal received through the broadcasting or the communication and extracts information added to the road information as well as registers the added information to the shared object, and the application of the other operating system controls the traveling speed of the one's own vehicle referring to the road information and the added information registered to the shared object and to the traveling environment information of the vicinity of the one's own vehicle.

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L12: Entry 50 of 131 File: USPT Feb 6, 2001

DOCUMENT-IDENTIFIER: US 6185496 B1
TITLE: Apparatus for controlling a vehicle based on road data

Abstract Text (1):
pg,2 A vehicle dynamic control system carries out smooth and natural vehicle dynamic control even when road data are discontinuous. In this system, a vehicle dynamic control value calculator calculates a vehicle dynamic control value based on vehicle running conditions and road data from a road data recognizer. The vehicle dynamic control value calculator, upon receipt of a discord signal and after a predetermined number of calculation cycles pass, reduces gradually the vehicle control value to 0 (zero). The calculator increases the vehicle dynamic control value gradually to a value corresponding to the road data and the vehicle running conditions in a predetermined number of calculation cycles, when reception of the discord signal is discontinued. When the calculator receives the discord signal but a predetermined number of calculation cycles are not counted yet, the vehicle dynamic control value is calculated based on road data previously detected.

Brief Summary Text (2):
This invention relates to a vehicle dynamic control system, which carries out vehicle dynamic control according to road data recognized thereby.

Brief Summary Text (3):
Currently developed are a variety of vehicle dynamic control techniques, utilizing a navigator or the like. Vehicle dynamic controls, such as warning control, deceleration control and so on, are carried out according to road data of the route in front of the vehicle, which are obtained by processing road map data inputted from the navigator.

Brief Summary Text (4):
In order to carry out such vehicle dynamic controls properly, it is required to accurately detect road data relating to the actual road in front of the vehicle. But road data fidelity can not be guaranteed when detecting road data by processing road map data from the navigator only.

Brief Summary Text (5):
Other technology, as disclosed by Japanese Patent Laid-Open No. 287395/1996, is presented, wherein cameras are installed for determining a road pattern, which is then transformed into road data. The road pattern is determined by projecting and transforming images taken by cameras, which are corrected by road inclination angle and radius curvature data, inputted from the navigator. Then, according to the road data, vehicle dynamic control is carried out.

Brief Summary Text (6):
Image data detected by sensors such as cameras are, however, subject to limitations due to weather and vehicle running conditions. Therefore, the system disclosed in Japanese Patent Laid-Open No. 287395/1996 may become remarkably degraded in its ability to, or can not, obtain precise road data, when the image data suddenly change depending on weather and vehicle running conditions.

Brief Summary Text (7):
In such a case, road data become discontinuous, bringing about difficulties in vehicle dynamic control, so that smooth control can not be carried out, resulting in not only an uncomfortable feeling for a driver, but also a risk due to strained control.

Brief Summary Text (9):
The present invention provides a vehicle dynamic control system which can carry out smooth and natural control even when road data become discontinuous.

Brief Summary Text (10):
In order to achieve the object, a vehicle dynamic control system according to the invention comprises: road data recognizing means for recognizing road data of a traveling route in front of a vehicle and vehicle dynamic control value calculating means for calculating vehicle dynamic control values to control vehicle movement based on the road data and the running conditions of the vehicle. The vehicle dynamic control value calculating means is characterized in that, once road data recognition becomes unreliable, vehicle dynamic control values are calculated for a predetermined time based on road data recognized just before the time when road data recognition became unreliable.

Brief Summary Text (11):
The vehicle dynamic control system according to another aspect of the invention includes the feature that the road data recognizing means judges that road data recognition becomes unreliable when road data is not available or the road data change suddenly.

Brief Summary Text (12):
The vehicle dynamic control system according to another aspect of the invention includes the feature that the road data recognizing means comprises a 1.sup.st (first) road data detecting means for detecting 1.sup.st (first) road data based on road map data, a 2.sup.nd (second) road data detecting means for detecting 2.sup.nd (second) road data based on road conditions which are detected, as the vehicle runs along the road, and a road data determining means for determining final road data based on the 1.sup.st road data and the 2.sup.nd road data when the 1.sup.st road data and the 2.sup.nd road data are about the same.

Brief Summary Text (13):
The vehicle dynamic control system according to another aspect of the invention includes the feature that the vehicle dynamic control value calculating means stops vehicle movement control when the road data recognizing means judges that the 1.sup.st road data and the 2.sup.nd road data are not same.

Brief Summary Text (14):
The vehicle dynamic control system according to another aspect of the invention includes the feature that the vehicle dynamic control value calculating means changes gradually the vehicle dynamic control values so that vehicle movement control is restrained when the road data recognizing means judges that the 1.sup.st road data and the 2.sup.nd road data are not the same.

Brief Summary Text (15):
The vehicle dynamic control system according to another aspect of the invention includes the feature that the vehicle dynamic control value calculating means gradually returns the vehicle dynamic control values to proper values corresponding to the road data and the vehicle running conditions when road data are recognized again by the road data recognizing means after the vehicle dynamic control value calculating means changes the vehicle dynamic control values so that vehicle movement control is restrained.

Brief Summary Text (17):
The vehicle dynamic control system according to another aspect of the invention includes the feature that the road data comprises at least a distance to the nearest curve.

Brief Summary Text (18):
The vehicle dynamic control system according to another aspect of the invention includes the feature that the road data comprises at least a radius of curvature of the nearest curve.

Brief Summary Text (19):

The vehicle dynamic control system according to another aspect of the invention includes the feature that the road data comprises at least a road width of the nearest curve.

Drawing Description Text (2):
FIG. 1 is a block diagram showing the general construction of a vehicle dynamic control system equipped with a road data recognizing device;

Drawing Description Text (3):
FIG. 2 is an illustration showing the construction of a 1.sup.st road data detector for detecting road data based on data from a navigator;

Drawing Description Text (7):
FIG. 6 is a flow chart showing vehicle dynamic control using a road data recognizing device according to the present invention;

Drawing Description Text (8):
FIG. 7 is a flow chart showing vehicle dynamic control using a road data recognizing device according to the present invention (continued from FIG. 6); and

Drawing Description Text (9):
FIG. 8 is a flow chart showing vehicle dynamic control using a road data recognizing device according to the present invention (continued from FIG. 7).

Detailed Description Text (3):
Referring to FIG. 1, reference number 1 generally indicates a vehicle dynamic control system. A controller 2 of the vehicle dynamic control system 1 consists mainly of a road data recognizer 3 and a vehicle dynamic control value calculator 4.

Detailed Description Text (4):
To the controller 2, a navigator 11 sends road width data and node data, representing road position and inflection, out of road map data and running information, such as vehicle position. A camera 12 sends the controller 2 data representing conditions of a road in front of the vehicle. A vehicle speed sensor 13 sends the controller 2 signals representing vehicle speed V. A steering wheel angle sensor (not shown), a yaw rate sensor (not shown) and a longitudinal acceleration sensor (not shown) send the controller 2 steering wheel angle data .theta.H, yaw rate data .gamma. and data representing vehicle running conditions, such as longitudinal acceleration, respectively.

Detailed Description Text (7):
The vehicle position detection sensor 11a gathers information related to vehicle position. The sensor 11a consists mainly of a GPS (Global Positioning System) receiver to receive positioning signals from GPS satellites so as to determine the position of the vehicle; a geomagnetic sensor to detect a running direction of the vehicle; and wheel speed sensors outputting pulse signals synchronized to wheel rotations.

Detailed Description Text (8):
The auxiliary memory 11b is a CD-ROM device, loading a CD-ROM storing road map information including road data and topographical data. The CD-ROM stores road map information in a plurality of hierarchal levels in various scales, and it further stores road kind information, i.e., motor ways, ordinary national roads and local roads, and passage conditions such as road widths and intersections. Road geometry data included in the road map information consist of node data with given intervals.

Detailed Description Text (9):
Road width data are reduced in several rankings as shown below and then stored:

Detailed Description Text (16):
A touch panel, as the control section 11d, is integrated in the display 11c to provide control functions, such as map scale change, and display switching for detailed place name display, area information display and route guidance display.

Detailed Description Text (17):
The processing unit 11e composes the vehicle running information inputted from the

vehicle position detection sensor 11a and the road map information registered from the auxiliary memory 11b, while conducting map matching and other processing. The results are sent to the display 11c following an operating signal sent from the control section 11d, so as to display the present position of the vehicle, a map of the neighborhood, an optimum route to the destination and other information. The node data are outputted to the road data recognizer 3, if necessary.

Detailed Description Text (18):
The camera 12 consists of, for instance, a pair of CCD cameras (not shown), taking a pair of stereoimages of objects in front of the vehicle by stereo photography. The pair of CCD cameras are used as outside object detecting means in this embodiment. A single CCD camera may be used instead of a pair of CCD cameras. Moreover, a super sonic sensor or an infrared sensor may substitute for the camera 12.

Detailed Description Text (19):
The warning device 14 consists of chimes, a buzzer, a voice warning generator or a warning light or a combination of the aforementioned. Sound warnings, e.g., a voice warning "Reduce speed for the curve in front," recorded in a CD-ROM of the navigator 11 or warning chimes/buzzer, is carried out at the warning level. A voice warning "Braking has been done," and a light warning are carried out at a level of forced braking.

Detailed Description Text (22):
The road data recognizer 3 mainly consists of a road geometry detector 5, a 1.sup.st (first) road data detector 6, a 2.sup.nd (second) road data detector 7, road data determiner 8 and a discord warning sender 10. The road data recognizer 3 calculates road data I within a predetermined range, e.g., 300 m in front, and outputs the data to the vehicle dynamic control value calculator 4.

Detailed Description Text (23):
A 1.sup.st (first) road data detecting means consists of the navigator 11, the road geometry detector 5 and the 1.sup.st (first) road data detector 6. The road geometry detector 5 calculates road geometry data of the road in front of the vehicle within a predetermined range, e.g., 300 m, based on inputted data from the navigator 11 and sends the road geometry data to the 1.sup.st (first) road data detector 6.

Detailed Description Text (24):
The road geometry data include the position (Xn, Yn) of a representative node Pn; distance Ln between node Pn-1 and node Pn; radius of curvature Rn; curve center On; curve angle .theta.n obtained from an angle formed by lines Pn-1 Pn and Pn Pn+1; a distance between node P-1 and curve starting point Lsn (the intersection point of line Pn-1 Pn and a perpendicular line from the curve center On to line Pn-1 Pn); and distance Lssn from the vehicle position to representative node Pn.

Detailed Description Text (25):
As shown in FIG. 2, the road geometry detector 5 mainly consists of a node detector 9a, a Pn-1 Pn distance calculator 9b, a Pn Pn+1 distance calculator 9c, a relative length judgment 9d, a mid-point calculator 9e, a mid-point-same-distance-point calculator 9f, a radius calculator 9g and a corrector 9h.

Detailed Description Text (26):
As shown in FIG. 5, out of the node data inputted from the navigator 11, the node detector 9a registers three consecutive nodes in the traveling direction of the vehicle or on the road selected by the driver, and names them the 1.sup.st (first) node Pn-1, the 2.sup.nd (second) node Pn and the 3.sup.rd (third) node Pn+1, in turn from the closest. From the registered three nodes, the positional information of the 1.sup.st (first) and 2.sup.nd (second) nodes, Pn-1 and Pn are outputted to the Pn-1 Pn distance calculator 9b, and the positional information of the 2.sup.nd (second) and 3.sup.rd (third) nodes, Pn and Pn+1, are outputted to the Pn Pn+1 distance calculator 9c. Positional data of Pn-1, Pn and Pn+1 are (Xn-1,Yn-1), (Xn, Yn) and (Xn+1, Yn+1), respectively. Pn is the representative node of them. The curve data at points P1, P2, . . . , and Pn are calculated by the node combinations of (P0, P1, P2), (P1, P2, P3), . . . and (Pn-1, Pn, Pn+1), respectively.

Detailed Description Text (39):

According to the positional data of the mid-point Pn-1,n inputted from the mid point calculator 9e and the positional data of a mid-point-same-distance-point Pn,n+1 calculated by the mid-point-same-distance-point calculator 9f, the radius calculator 9g, as shown in FIG. 3, determines the center "On" of the emerging curve on the road by creating the crossing point of a line that lies at a right angle to the shorter straight line (here, Pn-1 Pn) at the mid-point Pn-1,n and a line that lies at a right angle to the longer straight line (here, Pn Pn+1) at the mid-point-same-distance-point Pn,n+1. Then, the radius calculator 9g calculates the radius of curvature Rn of the curve. The calculation results are sent to the corrector 9h, and are determined as follows:

Detailed Description Text (46):
Road geometry data for each representative node Pn, which have been corrected by the corrector 9h or left intact because of the difference Deln being smaller than the given error value, are stored.

Detailed Description Text (47):
Here, the road data for representative node Pn include the position (Xn, Yn) of representative node Pn; distance Ln between node Pn-1 and node Pn; radius of curvature Rn; curve center On; curve angle .theta.n obtained from an angle formed by lines Pn-1 Pn and Pn Pn+1; a distance between node Pn-1 and curve starting point Lsn (the intersection point of the Pn-1 Pn line and a perpendicular line from curve center On to line Pn-1 Pn); and a distance Lssn from the vehicle position to representative node Pn.

Detailed Description Text (48):
The given error value depends on the road width data from the navigator 11 (road width D) and the shorter straight line distance judged by the relative length judgment 9d, thereby being represented as .alpha.D. (Here, .alpha. is a constant to be set in accordance with the shorter straight line distance, hereinafter referred to as a "node interval correction factor.") The wider the road width D, the bigger the given error value, resulting in less possibility of correction. That is to represent a reality that when a road width is wider, the radius of curvature is larger.

Detailed Description Text (49):
As with the node interval correction factor .alpha., the shorter the straight line distance, the larger the node interval correction factor .alpha., resulting in less possibility of correction. For example, when the shorter straight line distance is shorter than 20 m, .alpha. is 1.2, when the shorter straight line distance is between 20 m and 100 m, .alpha. is 0.6, and when the shorter straight line distance is longer than 100 m, .alpha. is 0.3. Short intervals of nodes represent that the road is accurately drawn by nodes on the map, i.e., less correction is necessary.

Detailed Description Text (56):
Because road geometry data are obtained from the road geometry detector 5 as described above, data of the nodes even with irregular intervals can be used as they are. Thus, the radius of curvature of a road to be traveled on can be determined quickly and accurately by simple calculation without data supplement or complex calculations.

Detailed Description Text (57):
The continuity of radiuses of curvature determined for respective nodes are natural, and the obtained data represent accurately an actual road geometry.

Detailed Description Text (59):
By providing the corrector 9h for the radius of curvature, it is possible to calculate the radius of curvature accurately. Furthermore, because the system allows the given error value to vary depending on actual road widths and node intervals, the calculations can be more accurate.

Detailed Description Text (60):
In other words, in order to represent a reality that when a road width is wider, the radius of curvature is larger, the system is set so that when the road width D is wider, the given error value is larger, resulting in less possibility of correction. In order to reflect the fact that short intervals of nodes represent that the road is accurately drawn by nodes on the map, the system is set so that the shorter the

straight line distance, the larger the node interval correction factor .alpha., resulting in less possibility of correction.

Detailed Description Text (61):
The road geometry data detected by the road geometry detector 5 are sent to the 1.sup.st (first) road data detector 6. The 1.sup.st (first) road data detector 6 picks out road geometry data for the nearest curve and calculates L1, a distance to the curve, e.g., a distance from the vehicle to the node representing the curve. The 1.sup.st (first) road data detector set (i.e., the 1.sup.st road data I1) comprises at least L1, which is the calculated distance to the curve, R1, which is the radius of curvature of the curve and the road width W1.

Detailed Description Text (62):
The 2.sup.nd (second) road data detecting means consists of the camera 12 and the 2.sup.nd (second) road data detector 7. The 2.sup.nd (second) road data detector 7 receives a pair of stereo images from in front of the car from the camera 12. The 2.sup.nd (second) road data detector determines distance data over the entire image field by way of trigonometric calculations according to the deflections of the positions of objects in each respective image, so as to generate a 3D-image showing distances, and recognizes the road being traveled on by carrying out a histogram processing of the distance distributions of the 3D-images. Thus the 2.sup.nd (second) road data detector sends the 2.sup.nd (second) road data, which represents the recognized road, to the road data determiner 8.

Detailed Description Text (63):
When recognizing that the road has a curve in front of the vehicle, the 2.sup.nd (second) road data detector 7 manages the curve with 2.sup.nd (second) road data I2 comprising at least L2, which is a distance to the curve, R2 which is the radius of curvature of the curve and the road width W2.

Detailed Description Text (72):
The road data determiner 8, i.e., road data determining means, receives the 1.sup.st (first) road data I1 and the 2.sup.nd (second) road data I2 from the 1.sup.st (first) road data detector 6 and the 2.sup.nd (second) road data detector 7, respectively. The road data determiner 8 determines the final road data I based on the 1.sup.st and 2.sup.nd road data I1 and I2, and sends the final road data to the vehicle dynamic control value calculator 4.

Detailed Description Text (73):
Firstly, the road data determiner 8 judges whether the 2.sup.nd (second) road data I2 is valid or not. Cases of invalidity are found when consideration of L2 reaches a judgment that there is no curve in front of the vehicle and when L2 and/or R2 change drastically at a calculation cycle. When the numbers do not return within a predetermined number of calculation cycles (e.g., 3 cycles) after the change occurs, the road data is judged invalid. During the predetermined number of cycles, the 2.sup.nd (second) road data I2 detected just before the change occurred is used.

Detailed Description Text (74):
When the 2.sup.nd (second) road data I2 is valid and when L1 and R1 of the 1.sup.st (first) road data I1 and L2 and R2 of the 2.sup.nd (second) road data I2 are regarded as the same (within predetermined ranges), the road data determiner 8 determines the road data I, which consists of the distance L to the curve, the radius of curvature R of the curve and the road width W.

Detailed Description Text (75):
The distance L, the radius of curvature R and the road width W are determined by taking averages of L1 and L2, R1 and R2 and W1 and W2. Determination of this data is not limited to the above methods. The larger values may be employed. Also, the more precise data out of the 1.sup.st road data and the 2.sup.nd road data may be employed considering the preciseness of the road map data of the navigator 11 and the detection preciseness of the camera 12.

Detailed Description Text (76):
At the establishment of the final road data I, accord in the road widths W1 and W2 within a predetermined range may be used in addition to the comparisons of L1 and L2

and R1 and R2.

Detailed Description Text (77):
The road data determiner 8 does not establish the road data I when discord is observed in either of L1/L2 and R1/R2. Then the road data determiner 8 establishes a discord flag, showing no establishment of road data I and sends a discord signal to the vehicle dynamic control value calculator 4, the 1.sup.st (first) road data detector 6 and the discord warning sender 10.

Detailed Description Text (78):
The road data determiner 8 establishes road data I by taking the 1.sup.st (first) road data I1, when the 2.sup.nd (second) road data I2 are invalid.

Detailed Description Text (79):
When the discord warning sender 10 receives the discord signal from the road data determiner 8, the discord sender 10 sends a discord warning signal so that the warning device 14 sends a discord warning which informs the driver that no road data is recognized. The discord warning is different from a warning to urge the driver to carry out braking.

Detailed Description Text (80):
Thus the road data recognizer 3 can exactly recognize road data of the running route in front of the vehicle because the road data recognizer 3 determines road data I while comparing the 1.sup.st (first) road data I1 which are formed based on data inputted from the navigator 11 and the 2.sup.nd (second) road data I2 which are formed based on data inputted from the camera 12. Namely, a road data detection limit of the navigator 11 can be supplemented. When there are differences between the stored data in the navigator 11 and the actual road conditions, because road construction is being done or the road has been changed, it can be recognized that data from the navigator 11 are erroneous.

Detailed Description Text (81):
The road data recognizer 3 can obtain road data securely overcoming difficulty due to bad weather or abrupt changes of running conditions, because the road data recognizer 3 determines road data I based on only the 1.sup.st (first) road data I1 when the 2.sup.nd (second) road data I2 is invalid.

Detailed Description Text (82):
The road data recognizer 3 does not establish road data I when the 1.sup.st (first) road data and the 2.sup.nd (second) road data do not fulfill predetermined conditions. Thus recognition of erroneous road data can be avoided, and an erroneous control because of erroneous road data can be prevented.

Detailed Description Text (83):
The vehicle dynamic control value calculator 4 calculates an aimed deceleration "At" based on inputted data from the road recognizer 3 and various signals representing vehicle running conditions, and makes warning control signals considering the actual deceleration of the vehicle against the aimed deceleration At. The signals are sent to the warning device 14, such as a buzzer, voice warning, warning light, to urge the driver to carry out vehicle control.

Detailed Description Text (85):
The vehicle dynamic control value calculator 4 calculates aimed deceleration At for the following four cases according to the situation of the discord flag to be established by the road data recognizer 3.

Detailed Description Text (88):
road data I is continually determined based on only 1.sup.st (first) road data I1 from the

Detailed Description Text (89):
navigator 11 if invalid 2.sup.nd (second) road data I2 from the camera 12 is obtained, or road

Detailed Description Text (90):

data I is continually determined based on both road data I1 and I2 after a term mentioned

Detailed Description Text (91):
later in case 4 has passed because the 2.sup.nd (second) road data I2 are valid and in accord

Detailed Description Text (92):
with the 1.sup.st (first) road data I1.

Detailed Description Text (93):
In this case, the vehicle dynamic control value calculator 4 determines an allowable lateral acceleration for the vehicle depending on road surface conditions such as friction .mu.. Then an allowable approaching speed V1, with which the vehicle can pass the curve safely, is determined based on the allowable lateral acceleration and the radius of curvature R of the road data I inputted from the road data determiner 8.

Detailed Description Text (97):
Case 2 represents a situation just after 1.sup.st (first) road data I1 from the navigator 11 is in

Detailed Description Text (98):
discord with 2.sup.nd road data I2 from the camera 12.

Detailed Description Text (99):
The vehicle dynamic control value calculator 4 corrects the aimed deceleration At determined in the situation of case 1 just before the establishment of the discord flag so that the At reduces cycle by cycle to 0 (zero) at the end of the predetermined calculation cycles, judging that it is impossible to carry out warning control by the warning device and vehicle movement control (speed down control) by the vehicle movement controller according to road data I.

Detailed Description Text (102):
Case 3 represents a situation that 1.sup.st road data I1 from the navigator 11 continuously

Detailed Description Text (103):
discords with 2.sup.nd road data I2 from the camera 12 after the duration of case 2.

Detailed Description Text (106):
Case 4 represents a situation just after starting of determining road data I by only 1.sup.st road

Detailed Description Text (107):
data I1, because of invalidity of 2.sup.nd road data I2 from the camera 12, or just after starting

Detailed Description Text (108):
of determining road data I based on both road data I1 and I2 because the 2.sup.nd (second) road

Detailed Description Text (109):
data I2 is valid and in accord with the 1.sup.st (first) road data I1.

Detailed Description Text (110):
The vehicle dynamic control value calculator 4 receives road data I. In such a case just after the discord flag is reset, required deceleration An determined based on the inputted road data I is sometimes quite different from the aimed deceleration At determined just before the discord flag is reset.

Detailed Description Text (111):
The vehicle dynamic control value calculator 4 corrects the aimed deceleration At determined in the preceding cycle by increasing it for a predetermined number of cycles gradually to the required deceleration An determined based on the road data I. Then the new aimed deceleration At is determined to be the corrected aimed

deceleration At.

Detailed Description Text (121):
Operations to be carried out by the controller 2 having the road data recognizer 3 according to the present invention are explained, referring to the flow charts shown in FIG. 6 through FIG. 8. This program is to be carried out every 0.1 second.

Detailed Description Text (123):
At S101, the 2.sup.nd (second) road data detector 7 detects road information in front of the vehicle by distance data processing and histogram processing. When the road has a curve, 2.sup.nd road data I2 including at least the distance L2 from the vehicle to the curve, the radius of curvature R and the road width W are calculated.

Detailed Description Text (124):
Following S101, S102 is carried out. At S102, the road geometry detector 5 calculates road geometry data at each node based on vehicle position data and node data inputted from the navigator 11. Then the program goes to S103.

Detailed Description Text (125):
At S103, the 1.sup.st (first) road data detector 6 picks out road geometry data for the nearest curve from the road data for each node calculated at S102, and calculates a distance to the curve L1, from the vehicle position to the node representing the curve. The 1.sup.st (first) road data detector establishes 1.sup.st road data I1 consisting of R1, which is the radius of curvature of the curve and road width W1, as well as L1, which is the calculated distance to the curve.

Detailed Description Text (126):
S104 through S107 are operations by the road data determiner 8. The road data determiner 8 receives the 1.sup.st (first) road data I1 stored in the 1.sup.st (first) road data detector 6, the 2.sup.nd (second) road data I2 detected by the 2.sup.nd (second) road data detector 7 at S102, vehicle position from the navigator 11 and vehicle speed V from the vehicle speed sensor 13.

Detailed Description Text (127):
At S104, it is judged whether there is any curve in front of the vehicle on the road recognized by the 2.sup.nd (second) road data detector, i.e., the distance to the curve L2 of the 2.sup.nd (second) road data I2 is checked. If yes, the program goes to S105. If not, the program goes to S106.

Detailed Description Text (138):
At S106, as a result of judgment at S104 that no curve exists or judgment at S105 that the 2.sup.nd (second) road data I2 are not reliable, the system checks the number of cycles where the situation of no curve is found to be in existence or where the 2.sup.nd road data I2 is found unreliable. If the number of the cycles is outside a predetermined number, e.g., 3, the program goes to S108, and then the 2.sup.nd road data I2 is judged as invalid at S108. The program then goes to S109.

Detailed Description Text (139):
On the other hand, when the number of the cycles is within a predetermined number, e.g., 3, the program goes to S107 where the previous 2.sup.nd (second) road data I2 is taken for the present 2.sup.nd (second) road data I2 and the 2.sup.nd (second) road data I2 is judged valid. Then the program goes to S109.

Detailed Description Text (140):
At S109, the system checks whether or not the 2.sup.nd (second) road data I2 are judged valid. If the 2.sup.nd (second) road data I2 are invalid, the program goes to S110. At S110, L1 (distance to the curve) and R1 (radius of curvature of the curve) based on the 1.sup.st (first) road data I1 are employed for the distance L and the radius R of the final road data I, and the system then goes to S116.

Detailed Description Text (141):
Even when the 2.sup.nd (second) road data I2 are invalid, the distance L to the curve and the radius of curvature R of the curve are established based on the 1.sup.st (first) road data I1. Namely, when the 2.sup.nd (second) road data I2 are not obtained due to bad running conditions or weather, the distance L to the curve and the radius

of curvature R of the curve still can be established.

Detailed Description Text (142):
When the 2.sup.nd (second) road data I2 are valid, the program goes to S111. At S111, L1 and L2 are compared. If the difference of L1 and L2 is within a predetermined range, e.g., 20 m, the program goes to S112.

Detailed Description Text (143):
At S112, the distance L to the curve of the final road data I is determined based on L1 and L2, and the system then goes to S113.

Detailed Description Text (146):
At S113, the system checks whether or not deflexion angles determined by the 1.sup.st (first) road data detector 6 and the 2.sup.nd (second) road data detector 7 are in accordance with each other. If yes, the system then goes to S114. At S114, the system checks whether radiuses R1 and R2 accord with each other within a predetermined range. If yes, then the system goes to S115.

Detailed Description Text (154):
At S115, the radius R is set for the final road data I based on R1 and R2, and the system then goes to S116.

Detailed Description Text (156):
When the 2.sup.nd (second) road data I2 are valid, the distance L and radius R are determined based on the 2.sup.nd (second) road data I2 and the 1.sup.st (first) road data I1 so that reliable data can be obtained.

Detailed Description Text (157):
At S116, as a result of the establishment of L and R for the final road data I at S110 or at S115, the program goes to S116. At S116, the discord flag is reset, and the system then goes to S118.

Detailed Description Text (158):
At S117, as a result of judgment at S111 that the difference between L1 and L2 is beyond the predetermined range, judgment at S113 that the deflexion angles discord, or judgment at S114 that R1 and R2 do not accord with each other within the predetermined range, a discord flag is established, representing a discord of the 1.sup.st (first) road data I1 based on the navigator 11 and the 2.sup.nd (second) road data I2 based on the camera 12. A discord signal showing establishment of the discord flag is sent to the vehicle dynamic control value calculator 4, the 1.sup.st (first) road data detector 6, and the discord warning sender 10. Then, the program goes to S119.

Detailed Description Text (159):
The discord warning sender 10 dispatches a discord warning to inform the driver of discord of the 1.sup.st (first) road data I1 and the 2.sup.nd (second) road data I2 through the warning device 14, upon receipt of the discord signal.

Detailed Description Text (160):
Thus, by giving the discord warning to driver, the driver is advised that there is a possibility that erroneous road geometry is stored in the navigator 11 due to road construction or modification of the road, or the camera 12 can not take exact image information, which may alert the driver of the need to proceed with care.

Detailed Description Text (161):
S118 through S122 are for the road geometry detector 5. When proceeding to S118 from S116, it is checked whether renewal of the road geometry data is necessary at S118.

Detailed Description Text (165):
At S120, road geometry data relating to the nodes P1 through Pk-1 are deleted, and the system then goes to S121. However, data of the curve represented by the node Pk-1, i.e., half of the curve length, radius of curvature Rk-1 and road width Wk-1, are not deleted because the curve still continues after the vehicle passes the node Pk.

Detailed Description Text (166):
At S121, the numbers of the road geometry data after the data deletion and the numbers

of node data inputted from the navigator 11 are compared so that the system can judge whether the inputted data from the navigator include new nodes or not. If yes, those new nodes are picked out, and the system then goes to S122.

Detailed Description Text (167):
At S122, road geometry data relating to the new nodes newly picked out are calculated, and the system then goes to S123.

Detailed Description Text (168):
The road geometry data include the position (Xn, Yn) of representative node Pn; distance Ln between node Pn-1 and node Pn; radius of curvature Rn; curve center On; curve angle .theta.n obtained from an angle formed by lines Pn-1 Pn and Pn Pn+1; a distance between node Pn-1 and the curve starting point Lsn (the intersection point of the line Pn-1 Pn and the line perpendicular from curve center On to the line Pn-1 Pn); and the distance Lssn from the vehicle position to representative node Pn.

Detailed Description Text (169):
At S119, as a result of establishment of a discord flag, all of the road geometry data are deleted, and the system then goes to S121. At S121, all data inputted from the navigator 11 are picked out as new data.

Detailed Description Text (170):
S123 through S128 are for the road data determiner 8. At S123, the 2.sup.nd (second) road data I2 is checked for validity and if valid, the system then goes to S124.

Detailed Description Text (171):
At S124, it is checked whether a difference between the road width W1 of the 1.sup.st (first) road data I1 determined at S103 and the road width W2 of the 2.sup.nd (second) road data I2 determined at S101 is within a predetermined range. If they accord with each other, the system then goes to S125, where the road width W is determined based on W1 and W2. Then the program goes to S127.

Detailed Description Text (172):
As for the judgment of accordance of the road widths W1 and W2, if W1 and W2 fall into one of the following four conditions, it is judged that W1 and W2 accord with each other:

Detailed Description Text (178):
Road width W is determined as the average of W1 and W2.

Detailed Description Text (179):
At S126, as a result of a judgment at S123 that the 2.sup.nd (second) road data I2 are invalid or judgment at S124 that W1 and W2 discord, the road width W is determined to be the value of W1. Then the program goes to S127.

Detailed Description Text (180):
At S127, it is judged whether the correction to the radius of curvature R determined at S110 or at S115 is necessary or not according to a determination of the road width W at S125 or at S126. If judged yes, the system then goes to S128.

Detailed Description Text (181):
At S128, it is checked if the radius R is reasonable given the road width W, and the radius R is corrected. Final road data I including the corrected radius R and the distance L determined at S110 or S112 are sent to the vehicle dynamic control value calculator 4, and then the program goes to S129

Detailed Description Text (182):
When it is judged at S127 that correction to the radius R is not necessary, final road data I including the radius R as it is and distance L are sent to the vehicle dynamic control value calculator 4, and then the program goes to S129.

Detailed Description Text (186):
When the program reaches S131, having passed through S129 and S130, the discord flag has been reset and cycles more than the predetermined number have passed since the resetting of the discord flag. At S131, the aimed deceleration At is determined based

on the road data I, and the warning control signal and the vehicle movement control signal are calculated, and then the program goes to an end.

Detailed Description Text (190):
When the road data recognizer 3 judges that 1.sup.st (first) road data I1 from the navigator 11 and 2.sup.nd (second) road data I2 from the camera 12 discord, the vehicle dynamic control value calculator 4 reduces gradually the aimed deceleration At to 0 (zero) in the predetermined cycles so that the warning control and the vehicle dynamic control can be prohibited smoothly.

Detailed Description Text (191):
When the discordance of the 1.sup.st and 2.sup.nd road data are resolved and the warning control and the vehicle movement control are about to be resumed, aimed deceleration At is gradually increased so that they are resumed smoothly.

Detailed Description Text (192):
According to the present invention as explained above, vehicle dynamic control value calculation can be done even when road data are discontinuous so that smooth and natural vehicle dynamic control can be carried out.

CLAIMS:

1. An apparatus for controlling a vehicle based on road data, comprising:

vehicle running condition detecting means for detecting running conditions of said vehicle;

road data detecting means for detecting road data including a curvature of a traveling route in front of said vehicle;

road data determining means for judging whether said road data is valid or invalid, and for determining that road data detection becomes unreliable when said road data is invalid for a predetermined time;

vehicle dynamic control value calculating means for calculating vehicle dynamic control values based on running conditions and said road data when said road data is valid, and for calculating vehicle dynamic control values based on said running conditions and valid road data detected before said road data was determined as invalid for said predetermined time, and for stopping the calculation of said vehicle dynamic control values using said invalid road data when road data detection becomes unreliable; and

vehicle movement control means for controlling said vehicle based on said vehicle dynamic control value.

3. The apparatus for controlling a vehicle according to claim 1, wherein said road data determining means judges that said road data is invalid when said road data change suddenly.

4. The apparatus for controlling a vehicle according to claim 1, wherein said road data determining means judges that said road data is invalid when said road data is unavailable.

5. An apparatus for controlling a vehicle based on road data, comprising:

vehicle running condition detection means for detecting running conditions of said vehicle;

first road data detecting means for detecting first road data of a traveling route in front of said vehicle based on road map data;

second road data detecting means for detecting second road data of a traveling route in front of said vehicle based on road conditions detected as said vehicle travels down the route;

road data determining means for determining final road data based on said first road data and said second road data when said first road data are about the same as said second road data;

vehicle dynamic control value calculating means for calculating vehicle dynamic control values based on said final road data; and

vehicle movement control means for controlling said vehicle based on said vehicle dynamic control values.

6. The apparatus for controlling a vehicle according to claim 5, wherein said final road data includes at least a distance to a nearest curve.

7. The apparatus for controlling a vehicle according to claim 5, wherein said final road data includes at least a radius of curvature of a nearest curve.

8. The apparatus for controlling a vehicle according to claim 5, wherein said final road data includes at least a road width of a nearest curve.

9. The apparatus for controlling a vehicle according to claim 5, wherein said vehicle dynamic control value calculating means stops calculating said vehicle dynamic control values when said road data determining means judges that said first road data are different from said second road data.

10. The apparatus for controlling a vehicle according to claim 5, wherein said vehicle dynamic control value calculating means decreases gradually said vehicle dynamic control values so as to restrain an amount of control of said vehicle when said road data determining means judges that said first road data are different from said second road data.

11. The apparatus for controlling a vehicle according to claim 5, wherein, when said first road data are determined to be different from said second road data and then at a later time said first road data are determined to be about the same as said second road data, said vehicle dynamic control value calculating means increases gradually said vehicle dynamic control values up to values corresponding to said first or second road data detected at the later time.

12. The apparatus for controlling a vehicle according to claim 5, wherein said road data determining means judges whether said second road data is valid or invalid, and when invalid, said road data determining means determines that said second road data detected immediately before said second road data became invalid as the second road data for a predetermined time while said second road data are judged as invalid.

13. The apparatus for controlling a vehicle according to claim 12, wherein said road data determining means judges that said second road data is unreliable when invalid second road data are detected for said predetermined time.

14. The apparatus for controlling a vehicle according to claim 5, wherein said vehicle dynamic control value calculating means calculates said vehicle dynamic control values using said vehicle dynamic control values calculated immediately before said first road data became different from said second road data.

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L12: Entry 4 of 131 File: USPT Feb 25, 2003

DOCUMENT-IDENTIFIER: US 6526352 B1
TITLE: Method and arrangement for mapping a road

Abstract Text (1):
Arrangement and method for mapping a road during travel of a vehicle having two data acquisition modules arranged on sides of the vehicle, each including a GPS receiver and antenna for enabling the vehicle's position to be determined and a linear camera which provides one-dimensional images of an area on the respective side in a vertical plane perpendicular to the road such that information about the road is obtained from a view in a direction perpendicular to the road. A processor unit forms a map database of the road by correlating the vehicle's position and the information about the road. Instead of or in addition to the linear cameras, scanning laser radars are provided and transmit waves downward in a plane perpendicular to the road and receive reflected waves to provide information about distance between the laser radars and the ground for use in forming the database.

Brief Summary Text (3):
This invention is in the fields of automobile safety, intelligent highway safety systems, accident avoidance, accident elimination, collision avoidance, blind spot detection, anticipatory sensing, automatic vehicle control, intelligent cruise control, vehicle navigation and other automobile, truck and train safety, navigation and control related fields.

Brief Summary Text (4):
The invention relates generally to methods for mapping a road in which a vehicle-mounted arrangement is used and the vehicle-mounted arrangement.

Brief Summary Text (5):
The invention also relates generally to an apparatus and method for precisely determining the location and orientation of a host vehicle operating on a roadway and location of multiple moving or fixed obstacles that represent potential collision hazards with the host vehicle to thereby eliminate collisions with such hazards. In the early stages of implementation of the apparatus and method and when collisions with such hazards cannot be eliminated, the apparatus and method will generate warning signals and initiate avoidance maneuvers to minimize the probability of a collision and the consequences thereof. More particularly, the invention relates to the use of a Global Positioning System ("GPS"), differential GPS ("DGPS"), other infrastructure-based location aids, cameras, radar and laser radar and an inertial navigation system as the primary host vehicle and target locating system with centimeter accuracy. The invention is further supplemented by a digital computer system to detect, recognize and track all relevant potential obstacles, including other vehicles, pedestrians, animals, and other objects on or near the roadway. More particularly, the invention further relates to the use of centimeter-accurate maps for determining the location of the host vehicle and obstacles on or adjacent the roadway. Even more particularly, the invention further relates to an inter-vehicle and vehicle to infrastructure communication systems for transmitting GPS and DGPS position data, as well as, relevant target data to other vehicles for information and control action, The present invention still further relates to the use of neural networks and neural-fuzzy rule sets for recognizing and categorizing obstacles and generating and developing optimal avoidance maneuvers where necessary.

Brief Summary Text (8):

When a person begins a trip using an automobile, he or she first enters the vehicle and begins to drive, first out of the parking space and then typically onto a local or city road and then onto a highway. In leaving the parking space, he or she may be at risk from an impact of a vehicle traveling on the road. The driver must check his or her mirrors to avoid such an event and several electronic sensing systems have been proposed which would warn the driver that a collision is possible. Once on the local road, the driver is at risk of being impacted from the front, side and rear, and electronic sensors are under development to warn the driver of such possibilities. Similarly, the driver may run into a pedestrian, bicyclist, deer or other movable object and various sensors are under development that will warn the driver of these potential events. These various sensors include radar, optical, infrared, ultrasonic. and a variety of others sensors, each of which attempts to solve a particular potential collision event. It is important to note that in none of these cases is there sufficient confidence in the decision that the a control of the vehicle is taken away from the driver. Thus, action by the driver is still invariably required.

Brief Summary Text (9):
In some proposed future Intelligent Transportation System (ITS) designs, hardware of various types is embedded into the highway and sensors which sense this hardware are placed onto the vehicle so that it can be accurately guided along a lane of the highway. In various other systems, cameras are used to track lane markings or other visual images to keep the vehicle in its lane. However, for successful ITS, additional information is needed by the driver, or the vehicle control system, to take into account weather, road conditions, congestion etc., which typically involves additional electronic hardware located on or associated with the highway as well as the vehicle. From this discussion, it is obvious that a significant number of new electronic systems are planned for installation onto automobiles. However, to date, no product has been proposed or designed which combines all of the requirements into a single electronic system. This is the intent of this invention.

Brief Summary Text (11):
Although it is technologically feasible, it is probably socially unacceptable at this time for a vehicle safety system to totally control the vehicle. The underlying premise of this invention, therefore, is that people will continue to operate their vehicle and control of the vehicle will only be seized by the control system when such an action is required to avoid an accident or when such control is needed for the orderly movement of vehicles through potentially congested areas on a roadway. When this happens, the vehicle operator will be notified and given the choice of exiting the road at the next opportunity. In some implementations, especially when this invention is first implemented on a trail basis, control will not be taken away from the vehicle operator but a warning system will alert the driver of a potential collision, road departure or other infraction.

Brief Summary Text (12):
Let us consider several scenarios and what information is required for the vehicle control process to prevent accidents. In one case, a driver is proceeding down a country road and falls asleep and the vehicle begins to leave the road, perhaps heading toward a tree. In this case, the control system would need to know that the vehicle was about to leave the road and for that it must know the position of the vehicle relative to the road. One method of accomplishing this would be to place a wire down the center of the road and to place sensors within the vehicle to sense the position of the wire relative to the vehicle. An alternate approach would be for the vehicle to know exactly where it is on the surface of the earth and to also know exactly where the edge of the road is.

Brief Summary Text (13):
These approaches are fundamentally different because in the former solution every road in the world would require the placement of appropriate hardware as well as the maintenance of this hardware. This is obviously impractical. In the second case, the use of the global positioning satellite system (GPS), augmented by additional systems to be described below, will provide the vehicle control system with an accurate knowledge of its location. Whereas it would be difficult to install and maintain hardware such as a wire down the center of the road for every road in the world, it is not difficult to survey every road and record the location of the edges, and the lanes for that matter, of each road. This information must then be made available through

one or more of a variety of techniques to the vehicle control system.

Brief Summary Text (14):
Another case might be where a driver is proceeding down a road and decides to change lines while another vehicle is in the driver's blind spot. Various companies are developing radar, ultrasonic or optical sensors to warn the driver if the blind spot is occupied. The driver may or may not heed this warning, perhaps due to an excessive false alarm rate, or he or she may have become incapacitated, or the system may fail to detect a vehicle in the blind spot and thus the system will fail.

Brief Summary Text (17):
Consider another example where water on the surface of a road is beginning to freeze. Probably the best way that a vehicle control system can know that the road is about to become slippery, and therefore that the maximum vehicle speed must be significantly reduced, is to get information from some external source. This source can be sensors located on the highway that are capable of determining this condition and communicating it to the vehicle. Alternately, the probability of icing occurring can be determined analytically from meteorological data and a historical knowledge of the roadway and communicated to the vehicle over a LEO satellite system, the Internet or an FM sub-carrier or other means. A combination of these systems can also be used.

Brief Summary Text (18):
Studies have shown that a combination of meteorological and historic data can accurately predict that a particular place on the highway will become covered with ice. This information can be provided to properly equipped vehicles so that the vehicle knows to anticipate slippery roads. For those roads that are treated with salt to eliminate frozen areas, the meteorological and historical data will not be sufficient. Numerous systems are available today that permit properly equipped vehicles to measure the coefficient of friction between the vehicle's tires and the road. It is contemplated that perhaps police or other public vehicles will be equipped with such a friction coefficient measuring apparatus and can serve as probes for those roadways that have been treated with salt. Information from these probe vehicles will be fed into the information system that will then be made available to control speed limits in the those areas.

Brief Summary Text (19):
Countless other examples exist, however, from those provided above it can be seen that for the vehicle control system to function without error, certain types of information must be accurately provided. These include information permitting the vehicle to determine its absolute location and means for vehicles near each other to communicate this location information to each other. Additionally, map information that accurately provides boundary and lane information of the road must be available. Also, critical weather or road-condition information is necessary. The road location information need only be generated once and changed whenever the road geometry is altered. This information can be provided to the vehicle through a variety of techniques including prerecorded media such as CD-ROM or DVD disks or through communications from transmitters located in proximity to the vehicle, satellites, radio and cellular phones.

Brief Summary Text (20):
Consider now the case of the congested highway. Many roads in the world are congested and are located in areas where the cost of new road construction is prohibitive or such construction is environmentally unacceptable. It has been reported that an accident on such a highway typically ties up traffic for a period of approximately four times the time period required to clear the accident. Thus, by eliminating accidents, a substantial improvement of the congested highway problem results. This of course is insufficient. On such highways, each vehicle travels with a different spacing, frequently at different speeds and in the wrong lanes. If the proper spacing of the vehicles could be maintained, and if the risk of an accident could be substantially eliminated, vehicles under automatic control could travel at substantially higher velocities and in a more densely packed configuration thereby substantially improving the flow rate of vehicles on the highway by as much as a factor of 3 to 4 times. This not only will reduce congestion but also improve air pollution. Once again, if each vehicle knows exactly where it is located, can communicate its location to surrounding vehicles and knows precisely where the road is

located, then the control system in each vehicle has sufficient information to accomplish this goal.

Brief Summary Text (22):
The information listed above is still insufficient. The geometry of a road or highway can be determined once and for all, until erosion or construction alters the road. Properly equipped vehicles can know their location and transmit that information to other properly equipped vehicles. There remains a variety of objects whose location is not fixed, which have no transmitters and which can cause accidents. These objects include broken down vehicles, animals such as deer which wander onto highways, pedestrians, bicycles, objects which fall off of trucks, and especially other vehicles which are not equipped with location determining systems and transmitters for transmitting that information to other vehicles. Part of this problem can be solved for congested highways by restricting access to these highways to vehicles that are properly equipped. Also, these highways are typically in urban areas and access by animals can be effectively eliminated. Heavy fines can be imposed on vehicles that drop objects onto the highway. Finally. since every vehicle and vehicle operator becomes part of the process, each such vehicle and operator becomes a potential source of information to help prevent catastrophic results. Thus, each vehicle should also be equipped with a system of essentially stopping the process in an emergency. Such a system could be triggered by vehicle sensors detecting a problem or by the operator strongly applying the brakes, rapidly turning the steering wheel or by activating a manual switch when the operator observes a critical situation but is not himself in immediate danger. An example of the latter case is where a driver witnesses a box falling off of a truck in an adjacent lane.

Brief Summary Text (24):
Once again, the operator will continue to control his vehicle provided he or she remains within certain constraints. These constraints are like a corridor. As long as the operator maintains his vehicle within this allowed corridor, he or she can operate that vehicle without interference from the control system. That corridor may include the entire width of the highway when no other vehicles are present or it may be restricted to all eastbound lanes, for example. In still other cases, that corridor may be restricted to a single line and additionally, the operator may be required to keep his vehicle within a certain spacing tolerance from the preceding vehicle. If a vehicle operator wishes to exit a congested highway, he could operate his turn signal that would inform the control system of this desire and permit the vehicle to safely exit from the highway. It can also inform other adjacent vehicles of the operator's intent, which could then automatically cause those vehicles to provide space for lane changing, for example. The highway control system is thus a network of individual vehicle control systems rather than a single highway resident computer system.

Brief Summary Text (26):
In the DOT. FY 2000 Budget in Brief Secretary Rodney Slater states that "Historic levels of federal transportation investment . . . are proposed in the FY 2000 budget." Later, Secretary Slater states that "Transportation safety is the number one priority." DOT has estimated that $165 billion per year are lost in fatalities and injuries on U.S. roadways. Another $50 billion are lost in wasted time of people on congested highways. Presented herein is a plan to eliminate fatalities and injuries and to substantially reduce congestion. The total cost of implementing this plan is minuscule compared to the numbers stated above. This plan has been named "The Road to Zero Fatalities.TM.", or RtZF.TM. for short.

Brief Summary Text (31):
A primary goal of the Intelligent Vehicle Initiative is to reduce highway related fatalities per 100 million vehicle miles traveled from 1.7 in 1996 to 1.6 in 2000. Of course the number of fatalities may still increase due to increased road use. If this reduction in fatalities comes about due to slower travel speeds, because of greater congestion, then has anything really been accomplished? Similar comments apply to the goal of reducing the rate of injury per 100 million vehicle miles from 141 in 1996 to 128 in 2000. An alternate goal is to have the technology implemented on all new vehicles by the year 2010 that will eventually eliminate all fatalities and injuries. As an intermediate milestone, it is proposed to have the technology implemented on all new vehicles by 2007 to reduce or eliminate fatalities caused by road departure, yellow line crossing, stop sign infraction, rear end and excessive speed accidents.

The invention described herein will explain how these are goals can be attained.

Brief Summary Text (34):
The final recommendations of the committee was "In the next five years, the IVI program should be judged on addressing selected impediments preventing deployment, not on the effect of IVI services on accident rates." This is a mistake. The emphasis for the next five years should be to deploy proven technologies and to start down the Road to Zero Fatalities.TM.. Five years from now technology should be deployed on production vehicles sold to the public that have a significant effect toward reducing fatalities and injuries.

Brief Summary Text (35):
As described in the paper "Preview Based Control of A Tractor Trailer Using DGPS For Preventing Road Departure Accidents" the basis of the technology proposed has been demonstrated.

Brief Summary Text (40):
U.S. Pat. No. 5,479,173 to Yoshioka, et al. uses a steering angle sensor, a yaw rate sensor and a velocity of the vehicle sensor to predict the path that the vehicle will take. It uses a radar unit to identify various obstacles that may be in the path of the vehicle, and it uses a CCD camera to try to determine that the road is changing direction in front of the vehicle. No mention is made of the accuracy with which these determinations are made. It is unlikely that sub-meter accuracy is achieved. If an obstacle is sensed the brakes can be automatically activated.

Brief Summary Text (43):
U.S. Pat. No. 5,613,039 to Wang, et al. is a collision warning radar system utilizing a real time adaptive probabilistic neural network. Wang discloses that 60% of roadway collisions could be avoided if the operator of the vehicle was provided warning at least one-half second prior to a collision. The radar system used by Wang consists of two separate frequencies. The reflective radar signals are analyzed by a probabilistic neural network that provides an output signal indicative of the likelihood and threat of a collision with a particular object. The invention further includes a Fourier transform circuit that converts the digitized reflective signal from a time series to a frequency representation. It is important to note that in this case, as in the others above, true collision avoidance will not occur since, without a knowledge of the roadway, two vehicles can be approaching each other on a collision course, each following a curved lane on a highway and yet the risk of collision is minimal due to the fact that each vehicle remains in its lane. Thus, true collision avoidance cannot be obtained without an accurate knowledge of the road geometry.

Brief Summary Text (44):
U.S. Pat. No. 5,983,161 to Lemelson describes a GPS-based collision avoidance and warning system that contains some of the features of the present invention. This patent is primarily concerned with using centimeter-accuracy DGPS systems to permit vehicles on a roadway to learn and communicate their precise locations to other vehicles. In that manner, a pending collision can, in some cases, be predicted.

Brief Summary Text (45):
Lemelson does not use an inertial navigation system for controlling the vehicle between GPS updates. Thus, the vehicle can travel a significant distance before its position can be corrected. This can lead to significant errors. Lemelson also does not make use of accurate map database and thus it is unable to distinguish cases where two cars are on separate lanes but on an apparent collision course. Although various radar and lidar systems are generally disclosed, the concept of range gating is not considered. Thus, the Lemelson system is unable to provide the accuracy and reliability required by the Road to Zero Fatalities system described herein.

Brief Summary Text (46):
b. Accurate Navigation

Brief Summary Text (47):
U.S. Pat. No. 5,504,482 to Schreder describes an automobile equipped with an inertial and satellite navigation system as well as a local area digitized street map. The main use of this patent is for route guidance in the presence of traffic jams, etc.

Schreder describes how information as to the state of the traffic on a highway can be transmitted and utilized by a properly equipped vehicle to change the route the driver would take in going to his destination. Schreder does not disclose sub-meter vehicle location accuracy determination, nevertheless, this patent provides a good picture of the state of the art as can be seen from the following quoted paragraphs:

Brief Summary Text (48):
". . . there exists a wide range of technologies that have disadvantageously not been applied in a comprehensive integrated manner to significantly improve route guidance, reduce pollution, improve vehicular control and increase safety associated with the common automobile experience. For example, it is known that gyro based inertial navigation systems have been used to generate three-dimensional position information, including exceedingly accurate acceleration and velocity information over a relatively short travel distance, and that GPS satellite positioning systems can provide three-dimensional vehicular positioning and epoch timing, with the inertial system being activated when satellite antenna reception is blocked during "drop out" for continuous precise positioning. It is also known that digitized terrain maps can be electronically correlated to current vehicular transient positions, as have been applied to military styled transports and weapons. For another example, it is also known that digitally encoded information is well suited to RF radio transmission within specific transmission carrier bands, and that automobiles have been adapted to received AM radio, FM radio, and cellular telecommunication RF transmissions. For yet another example, it is further known that automobile electronic processing has been adapted to automatically control braking, steering, suspension and engine operation, for example, anti-lock braking, four-wheel directional steering, dynamic suspension stiffening during turns and at high speeds, engine governors limiting vehicular speed, and cruise control for maintaining a desired velocity. For still another example, traffic monitors, such as road embedded magnetic traffic light sensor loops and road surface traffic flow meters have been used to detect traffic flow conditions. While these sensors, meters, elements, systems and controls have served limited specific purposes, the prior art has disadvantageously failed to integrate them in a comprehensive fashion to provide a complete dynamic route guidance, dynamic vehicular control, and safety improvement system."

Brief Summary Text (49):
"Recently, certain experimental integrated vehicular dynamic guidance systems have been proposed. Motorola has disclosed an Intelligent Vehicle Highway System in block diagram form in copyright dated 1993 brochure. Delco Electronics has disclosed another Intelligent Vehicle Highway System also in block diagram form in Automotive News published on Apr. 12, 1993. These systems use compass technology for vehicular positioning. However, displacement wheel sensors are plagued by tire slippage, tire wear and are relatively inaccurate requiring recalibration of the current position. Compasses are inexpensive, but suffer from drifting particularly when driving on a straight road for extended periods. Compasses can sense turns, and the system may then be automatically recalibrated to the current position based upon sensing a turn and correlating that turn to the nearest turn on a digitized map, but such recalibration, is still prone to errors during excessive drifts. Moreover, digitized map systems with the compass and wheel sensor positioning methods operate in two dimensions on a three dimensional road terrain injecting further errors between the digitized map position and the current vehicular position due to a failure to sense the distance traveled in the vertical dimension."

Brief Summary Text (50):
"These Intelligent Vehicle Highway Systems appear to use GPS satellite reception to enhance vehicular tracking on digitized road maps as part of a guidance and control system. These systems use GPS to determine when drift errors become excessive and to indicate that recalibration is necessary. However, the GPS reception is not used for automatic accurate recalibration of current vehicular positioning, even though C-MIGITS and like devices have been used for GPS positioning, inertial sensing and epoch time monitoring, which can provide accurate continuous positioning."

Brief Summary Text (51):
"These Intelligent Vehicle Highway Systems use the compass and wheel sensors for vehicular positioning for route guidance, but do not use accurate GPS and inertial route navigation and guidance and do not use inertial measuring units for dynamic

vehicular control. Even though dynamic electronic vehicular control, for example, anti-lock braking, anti-skid steering, and electronic control suspension have been contemplated by others, these systems do not appear to functionally integrate these dynamic controls with an accurate inertial route guidance system having an inertial measuring unit well suited for dynamic motion sensing. There exists a need to further integrate and improve these guidance systems with dynamic vehicular control and with improved navigation in a more comprehensive system."

Brief Summary Text (52):
"These Intelligent Vehicle Highway Systems also use RF receivers to receive dynamic road condition information for dynamic route guidance, and contemplate infrastructure traffic monitoring, for example, a network for road magnetic sensing loops, and contemplate the RF broadcasting of dynamic traffic conditions for dynamic route guidance. The disclosed two-way RF communication through the use of a transceiver suggests a dedicated two-way RF radio data system. While two-way RF communication is possible, the flow of necessary information between the vehicles and central system appears to be exceedingly lopsided. The flow of information from the vehicles to a central traffic radio data control system may be far less than the required information from traffic radio data control system to the vehicles. It seems that the amount of broadcasted dynamic traffic flow information to the vehicles would be far greater than the information transmitted from the vehicles to the central traffic control center. For example, road side incident or accident emergency, messages to a central system may occur far less than the occurrences of congested traffic points on a digitized map having a large number of road coordinate points."

Brief Summary Text (55):
Three attempts to improve the position accuracy of GPS are discussed here, the Wide Area Augmentation System (WAAS), the Local Area Augmentation System (LAAS) and various systems that make use of the carrier phase.

Brief Summary Text (56):
A paper by S. Malys et al., titled "The GPS Accuracy Improvement Initiative" provides a good discussion of the errors inherent in the GPS system without using differential corrections. It is there reported that the standard GPS provides a 9-meter RMS 3-D navigational accuracy to authorize precise positioning service users. This reference indicates that there are improvements planned in the GPS system that will further enhance its accuracy. The accuracies of these satellites independently of the accuracies of receiving units is expected to be between 1 and 1.5 meters RMS. Over the past eight years of GPS operations, a 50% (4.6 meter to 2.3 meter) performance improvement has been observed for the signal in space range errors. This, of course, is the RMS error. The enhancements contained in the accuracy improvement initiative will provide another incremental improvement from the current 2.3 meters to 1.3 meters and perhaps to as low as 40 centimeters.

Brief Summary Text (58):
From a paper by J. F. Zumberge, M. M. Watkins and F. H. Webb, titled "Characteristics and Applications of Precise GPS Clock Solutions Every 30 Seconds", Journal of the Institute of Navigation, Vol. 44, No. 4, Winter 1997-1998, it appears that using the techniques described in this reference that the WAAS system could eventually be improved to provide accuracies in the sub-decimeter range for moving vehicles without the need for differential other GPS systems. This data would be provided every 30 seconds.

Brief Summary Text (59):
W. I. Bertiger et al., "A Real-Time Wide Area Differential GPS System", Journal of the Institute of Navigation, Vol. 44. No. 4, Winter 1997-1998. This paper describes the software that is to be used with the WAAS System. The WAAS System is to be completed by 2001. The goal of the research described in this paper is to achieve sub-decimeter accuracies worldwide, effectively equaling local area DGPS performance worldwide. The full computation done on a Windows NT computer adds only about 3 milliseconds. The positioning accuracy is approximately 25 centimeters in the horizontal direction. That is the RMS value so that gives an error at .+-.3 sigma of 1.5 meters. Thus, this real time wide area differential GPS system is not sufficiently accurate for the purposes of this invention. Other systems claim higher accuracies.

Brief Summary Text (60):
According to the paper by R. Braff, titled "Description of the FAA's Local Area Augmentation System (LAAS)", Journal of the Institute of Navigation, Vol. 44, No. 4, Winter 1997-1998, the LAAS System is the FAA's ground-based augmentation system for local area differential GPS. It is based on providing corrections of errors that are common to both ground-based and aircraft receivers. These corrections are transmitted to the user receivers via very high frequency VHF, line of sight radio broadcast. LAAS has the capability of providing accuracy on the order of 1 meter or better on the final approach segment and through rollout. LAAS broadcasts navigational information in a localized service volume within approximately 30 nautical miles of the LAAS ground segment.

Brief Summary Text (61):
O'Connor, Michael, Bell, Thomas, Elkaim, Gabriel and Parkinson, Bradford, "Automatic Steering of Farm Vehicles Using GPS" describes an automatic steering system for farm vehicles where the vehicle lateral position error never deviated by more than 10 centimeters, using a carrier phase differential GPS system whereby the differential station was nearby.

Brief Summary Text (62):
The following quote is from Y. M. Al-Haifi et al., "Performance Evaluation of GPS Single-Epoch On-the Fly Ambiguity Resolution", Journal of the Institute of Navigation, Vol. 44, No. 4, Winter 1997-1998. This technique demonstrates sub-centimeter precision results all of the time provided that at least five satellites are available and multipath errors are small. A resolution of 0.001 cycles is not at all unusual for geodetic GPS receivers. This leads to a resolution on the order of 0.2 millimeters. In practice, multipath affects, usually from nearby surfaces, limit the accuracy achievable to around 5 millimeters. It is currently the case that the reference receiver can be located within a few kilometers of the mobile receiver. In this case, most of the other GPS error sources are common. The only major problem, which needs to be solved to carry out high precision kinematic GPS, is the integer ambiguity problem. This is because at any given instant the whole number of cycles between the satellite and the receiver is unknown. The recovery of the unknown whole wavelengths or integer ambiguities is therefore of great importance to precise phase positioning. Recently, a large amount of research has focused on so called on the fly (OTF) ambiguity resolution methodologies in which the integer ambiguities are solved for while the unknown receiver is in motion.

Brief Summary Text (63):
The half-second processing time required for this paper represents 44 feet of motion for a vehicle traveling at 60 mph, which would be intolerable unless supplemented by an inertial navigation system. The basic guidance system in this case would have to be the laser or MEMS gyro on the vehicle. With a faster PC, one-tenth a second processing time would be achievable, corresponding to approximately 10 feet of motion of the vehicle, putting less reliance on the laser gyroscope. Nowhere in this paper is the use of this system on automobiles suggested. The technique presented in this paper is a single epoch basis (OTF) ambiguity resolution procedure that is insensitive to cycle slips. This system requires the use of five or more satellites which suggests that additional GPS satellites may need to be launched to make the smart highway system more accurate.

Brief Summary Text (64):
F. van Diggelen. "GPS and GPS+GLONASS RTK", ION-GPS, September 1997 "New Products Descriptions", gives a good background of real time kinematic systems using the carrier frequency. The products described in this paper illustrate the availability of centimeter level accuracies for the purposes of the RtZF system. The product described in F. van Diggelen requires a base station that is no further than 20 kilometers away.

Brief Summary Text (65):
A paper by J. Wu and S. G. Lin, titled "Kinematic Positioning with GPS Carrier Phases by Two Types of Wide Laning", Journal of the Institute of Navigation, Vol. 44, No. 4, Winter 1997 discloses that the solution of the integer ambiguity problem can be simplified by performing other constructs other than the difference between the two phases. One example is to use three times one phase angle, subtracted from four times

another phase angle. This gives a wavelength of 162.8 centimeters vs. 86.2 for the single difference. Preliminary results with a 20-kilometer base line show a success rate as high as 95% for centimeter level accuracies.

Brief Summary Text (66):
A paper by R. C. Hayward et al., titled "Inertially Aided GPS Based Attitude Heading Reference System (AHRS) for General Aviation Aircraft" provides the list of inertial sensors that can be used with the teachings of this invention.

Brief Summary Text (67):
K. Ghassemi et al., "Performance Projections of GPS IIF", describes the performance objectives for a new class of GPS 2F satellites to be launched in late 2001.

Brief Summary Text (68):
Significant additional improvement can be obtained for the WAAS system using the techniques described in the paper "Incorporation of orbital dynamics to improve wide-area differential GPS" which is included herein by reference.

Brief Summary Text (70):
U.S. Pat. No. 5,272,483 to Kato describes an automobile navigation system. This invention attempts to correct for the inaccuracies in the GPS system through the use of an inertial guidance, geomagnetic sensor, or vehicle crank shaft speed sensor. However, it is unclear as to whether the second position system is actually more accurate than the GPS system. This combined system, however, cannot be used for sub-meter positioning of an automobile.

Brief Summary Text (71):
U.S. Pat. No. 5,383,127 to Shibata uses map matching algorithms to correct for errors in the GPS navigational system to provide a more accurate indication of where the vehicle is or, in particular, on what road the vehicle is. This procedure does not give sub-meter accuracy. Its main purpose is for navigation and, in particular, in determining the road on which the vehicle is traveling.

Brief Summary Text (72):
U.S. Pat. No. 5,416,712 to Geier, et al. relates generally to navigation systems and more specifically to global positioning systems that use dead reckoning apparatus to fill in as backup during periods of GPS shadowing such as occur amongst obstacles, e.g., tall buildings in large cities. This patent shows a method of optimally combining the information available from GPS even when less than 3 or 4 satellites are available with information from a low-cost, inertial gyro, having errors that range from 1-5%. This patent provides an excellent analysis of how to use a modified Kalman filter to optimally use the available information.

Brief Summary Text (73):
U.S. Pat. No. 5,606,506 to Kyrtsos provides a good background of the GPS satellite system. It discloses a method for improving the accuracy of the GPS system using an inertial guidance system. This is based on the fact that the GPS signals used by Kyrtsos do not contain a differential correction and the selective access feature is on. Key paragraphs from this application that is applicable to the instant invention follow.

Brief Summary Text (74):
"Several national governments, including the United States (U.S.) of America, are presently developing a terrestrial position determination system, referred to generically as a global positioning system (GPS). A GPS is a satellite-based radio-navigation system that is intended to provide highly accurate three-dimensional position information to receivers at or near the surface of the Earth.

Brief Summary Text (75):
"The U.S. government has designated its GPS the "NAVSTAR." The NAVSTAR GPS is expected to be declared fully operational by the U.S. government in 1993. The government of the former Union of Soviet Socialist Republics (USSR) is engaged in the development of a GPS known as "GLONASS". Further, two European systems known as "NAVSAT" and "GRANAS" are also under development. For ease of discussion, the following disclosure focuses specifically on the NAVSTAR GPS. The invention, however, has equal applicability to

other global positioning systems. "In the NAVSTAR GPS, it is envisioned that four orbiting GPS satellites will exist in each of six separate circular orbits to yield a total of twenty-four GPS satellites. Of these, twenty-one will be operational and three will serve as spares. The satellite orbits will be neither polar nor equatorial but will lie in mutually orthogonal inclined planes."

Brief Summary Text (76):
"Each GPS satellite will orbit the Earth approximately once every 12 hours. This coupled with the fact that the Earth rotates on its axis once every twenty-four hours causes each satellite to complete exactly two orbits while the Earth turns one revolution."

Brief Summary Text (77):
"The position of each satellite at any given time will be precisely known and will be continuously transmitted to the Earth. This position information, which indicates the position of the satellite in space with respect to time (GPS time), is known as ephemeris data."

Brief Summary Text (78):
"In addition to the ephemeris data, the navigation signal transmitted by each satellite includes a precise time at which the signal was transmitted. The distance or range from a receiver to each satellite may be determined using this time of transmission which is included in each navigation signal. By noting the time at which the signal was received at the receiver, a propagation time delay can be calculated. This time delay when multiplied by the speed of propagation of the signal will yield a "pseudorange" from the transmitting satellite to the receiver."

Brief Summary Text (79):
"The range is called a "pseudorange" because the receiver clock may not be precisely synchronized to GPS time and because propagation through the atmosphere introduces delays into the navigation signal propagation times. These result, respectively, in a clock bias (error) and an atmospheric bias (error). Clock biases may be as large as several milliseconds."

Brief Summary Text (82):
"Triangulation, using at least three of the orbiting GPS satellites, allows the absolute terrestrial position (longitude, latitude, and altitude with respect to the Earth's center) of any Earth receiver to be computed via simple geometric theory. The accuracy of the position estimate depends in part on the number of orbiting GPS satellites that are sampled. Using more GPS satellites in the computation can increase the accuracy of the terrestrial position estimate."

Brief Summary Text (83):
"Conventionally, four GPS satellites are sampled to determine each terrestrial position estimate. Three of the satellites are used for triangulation, and a fourth is added to correct for the clock bias described above. If the receiver's clock were precisely synchronized with that of the GPS satellites, then this fourth satellite would not be necessary. However, precise (e.g., atomic) clocks are expensive and are, therefore, not suitable for all applications."

Brief Summary Text (84):
"For a more detailed discussion on the NAVSTAR GPS, see Parkinson, Bradford W. and Gilbert, Stephen W., "NAVSTAR: Global Positioning System--Ten Years Later, "Proceedings of the WEEE, Vol. 71, No. 10, October 1983; and GPS: A Guide to the Next Utility, published by Trimble Navigation Ltd., Sunnyvale, Calif., 1989, pp. 147, both of which are incorporated herein by reference. For a detailed discussion of a vehicle positioning/navigation system which uses the NAVSTAR GPS, see commonly owned U.S. patent application Ser. No. 07/628,560, entitled "Vehicle Position Determination System and Method," filed Dec. 3, 1990, which is incorporated herein by reference."

Brief Summary Text (85):
"The NAVSTAR GPS envisions two modes of modulation for the carrier wave using pseudorandom signals. In the first mode, the carrier is modulated by a "C/A signal" and is referred to as the "Coarse/Acquisition mode". The Coarse/Acquisition or C/A mode is also known as the "Standard Positioning Service". The second mode of

modulation in the NAVSTAR GPS is commonly referred to as the "precise" or "protected" (P) mode. The P-mode is also known as the "Precise Positioning Service".

Brief Summary Text (86):
The P-mode is intended for use only by Earth receivers specifically authorized by the United States government. Therefore, the P-mode sequences are held in secrecy and are not made publicly available. This forces most GPS users to rely solely on the data provided via the C/A mode of modulation (which results in a less accurate positioning system).

Brief Summary Text (87):
"Moreover, the U.S. government (the operator of the NAVSTAR GPS) may at certain times introduce errors into the C/A mode GPS data being transmitted from the GPS satellites by changing clock and/or ephemeris parameters. That is, the U.S. government can selectively corrupt the GPS data. The ephemeris and/or the clock parameters for one or more satellites may be slightly or substantially modified. This is known as "selective availability" or simply SA. SA may be activated for a variety of reasons, such as national security."

Brief Summary Text (88):
"When SA is activated, the U.S. government is still able to use the NAVSTAR GPS because the U.S. government has access to the P-mode modulation codes. The C/A mode data, however, may be rendered substantially less accurate."

Brief Summary Text (89):
"In addition to the clock error, the atmospheric error and errors from selective availability, other errors which affect GPS position computations include receiver noise, signal reflections, shading, and satellite path shifting (e.g., satellite wobble). These errors result in computation of incorrect pseudoranges and incorrect satellite positions. Incorrect pseudoranges and incorrect satellite positions, in turn, lead to a reduction in the precision of the position estimates computed by a vehicle positioning system."

Brief Summary Text (91):
U.S. Pat. No. 5,757,646 to Talbot, et al. illustrates the manner in which centimeter level accuracy on the fly in real time is obtained. It is accomplished by double differencing the code and carrier measurements from a pair of fixed and roving GPS receivers. This patent also presents an excellent discussion of the problem and of various prior solutions as in the following paragraphs:

Brief Summary Text (92):
"When originally conceived, the global positioning system (GPS) that was made operational by the United States Government was not foreseen as being able to provide centimeter-level position accuracies. Such accuracies are now conmmonplace."

Brief Summary Text (93):
"Extremely accurate GPS receivers depend on phase measurements of the radio carriers that they receive from various orbiting GPS satellites. Less accurate GPS receivers simply develop the pseudoranges to each visible satellite based on the time codes being sent. Within the granularity of a single time code, the carrier phase can be measured and used to compute range distance as a multiple of the fundamental carrier wavelength. GPS signal transmissions are on two synchronous, but separate carrier frequencies "L1" and "L2", with wavelengths of nineteen and twenty-four centimeters, respectively. Thus within nineteen or twenty-four centimeters, the phase of the GPS carrier signal will change 360.degree.."

Brief Summary Text (94):
"However the numbers of whole cycle (360.degree.) carrier phase shifts between a particular GPS satellite and the GPS receiver must be resolved. At the receiver, every cycle will appear the same. Therefore there is an "integer ambiguity". The computational resolution of the integer ambiguity has traditionally been an intensive arithmetic problem for the computers used to implement GPS receivers. The traditional approaches to such integer ambiguity resolution have prevented on-the-fly solution measurement updates for moving GPS receivers with centimeter accurate outputs. Very often such highly accurate GPS receivers have required long periods of motionlessness

to produce a first and subsequent position fix."

Brief Summary Text (95):
"There are numerous prior art methods for resolving integer ambiguities. These include integer searches, multiple antennas, multiple GPS observables, motion-based approaches, and external aiding. Search techniques often require significant computation time and are vulnerable to erroneous solutions when only a few satellites are visible. More antennas can improve reliability considerably. If carried to an extreme, a phased array of antennas results whereby the integers are completely unambiguous and searching is unnecessary. But for economy the minimum number of antennas required to quickly and unambiguously resolve the integers, even in the presence of noise, is preferred."

Brief Summary Text (96):
"One method for integer resolution is to make use of the other observables that modulate a GPS timer. The pseudo-random code can be used as a coarse indicator of differential range, although it is very susceptible to multipath problems. Differentiating the L1 and L2 carriers provides a longer effective wavelength, and reduces the search space. However dual frequency receivers are expensive because they are more complicated. Motion-based integer resolution methods make use of additional information provided by platform or satellite motion. But such motion may not always be present when it is needed."

Brief Summary Text (101):
A paper by O'Shea, Michael and Shuman, Valerie entitled "Looking Ahead: Map Databases in Predictive Positioning And Safety Systems" discusses map databases which can assist radar and image-processing systems of this invention since the equipped vehicle would know where the road ahead is and can therefore distinguish the lane of the preceding vehicle. No mention, however, is made in this reference of how this is accomplished through range gating or other means. This reference also mentions that within five years it may be possible to provide real time vehicle location information of one-meter accuracy. However, it mentions that this will be limited to controlled access roads such as interstate highways. In other words, the general use of this information on all kinds of roads for safety purposes is not contemplated. This reference also states that "road geometry, for example, may have to be accurate to within one meter or less as compared to the best available accuracy of 15 meters today". This reference also mentions the information about lane configuration that can be part of the database including the width of each lane, the number of lanes, etc., and that this can be used to determine driver drowsiness. This reference also states that "at normal vehicle speeds, the vehicle location must be updated every few milliseconds. It is also stated that the combination of radar and map data can also help to interpret radar information such as the situation where a radar system describes an overpass as a semi truck . . . " Image processing in this reference is limited to assessing road conditions such as rain, snow, etc. The use of a laser radar system is not contemplated by this reference. The use of this information for road departures warnings is also mentioned, as is lane following. The reference also mentions that feedback from vehicles can be used to improve map configurations.

Brief Summary Text (104):
U.S. Pat. No. 5,367,463 to Tsuji describes a vehicle azimuth determining system. It uses regression lines to find the vehicle on a map when there are errors in the GPS and map data. This patent does not give sub-meter accuracy. The advantage of this invention is that it shows a method of combining both map matching data and GPS along with a gyro and a vehicle velocity and odometer data to improve the overall location accuracy of the vehicle.

Brief Summary Text (106):
U.S. Pat. No. 5,530,651 to Uemura, et al. discloses a combination of an ultrasonic and laser radar optical detection system which has the ability to detect soiled lenses, rain, snow, etc. The vehicle control system then automatically limits the speed, for example, that the vehicle can travel in adverse weather conditions. The speed of the vehicle is also reduced when the visibility ahead is reduced due to a blind, curved corner. The permitted speed is thus controlled based on weather conditions and road geometry. There is no information in the vehicle system as to the legal speed limit as provided for in the instant invention.

Brief Summary Text (108):
When the operator begins operating his vehicle with a version of the RtZF system of this invention, he or she will probably not be near a reference point as determined by the MIR or RFID locator system, for example. In this situation, he or she will use the standard GPS system with the WAAS or other DGPS corrections. This will provide accuracy of between a few meters to 6 centimeters. This accuracy might be further improved as he or she travels down the road through map-matching or through communication with other vehicles. The vehicle will know, however, that is not operating in the high accuracy mode. As soon as the vehicle passes an MRI, RFID or equivalent precise positioning system, it will be able to calculate exactly where it is within a few centimeters and the vehicle will know that it is in the accurate mode. Naturally, any travel on a controlled highway would require frequent MIR, RFID or equivalent stations and the vehicle can be accurately contained within its proper corridors. Also, the size of the corridors that the vehicle is permitted to travel in can be a function of the accuracy state of the vehicle.

Brief Summary Text (109):
A paper by Han, Shaowei entitled "Ambiguity Recovery For Long-Range GPS Kinematic Positioning" appears to say that if a mobile receiver is initially synchronized with a fixed receiver such that there is no integer ambiguity, and if the mobile receiver then travels away from the fixed receiver, and during the process it loses contact with the satellites for a period of up to five minutes, that the carrier phase can be recovered and the ambiguity eliminated, providing again centimeter-range accuracies. Presumably the fixed station is providing the differential corrections. This is important for the instant invention since the integer ambiguity can be eliminated each time the vehicle passes a precise positioning station such as the MIR or RFID triad or equivalent as explained below. After that, a five-minute loss of GPS signals should never occur. Thus, carrier phase accuracies will eventually be available to all vehicles.

Brief Summary Text (110):
This concept can be further expanded upon. If two vehicles are traveling near each other and have established communication, and assuming that each vehicle can observe at least four of the same GPS satellites, each vehicle can send the satellite identification and the time of arrival of the signal at a particular epoch to the other. Then each vehicle can determine the relative position of the other vehicle as well as the relative clock error. As one vehicle passes a Precise Positioning Station (PPS), it knows exactly where it is and thus the second vehicle also knows exactly where it is and can correct for satellite errors. All vehicles that are in communication with the vehicle at the PPS similarly can determine their exact position and the system again approaches perfection. This concept is based on the fact that the errors in the satellite signals are identical for all vehicles that are within a mile or so of each other.

Brief Summary Text (130):
There are one million, sixty-nine thousand, twenty-two miles of paved non-local roads in the US. Eight hundred twenty-one thousand and four miles of these are classified as "rural" and the remaining two hundred forty-eight thousand, eighteen miles are "urban".

Brief Summary Text (131):
The existing interstate freeway system consists of approximately 50,000 miles which is 1% of the total of 3.8 million miles of roads. Freeways make up 3% of the total urban/suburban arterial mileage and carry approximately 30% of the total traffic.

Brief Summary Text (132):
In one study, dynamic route guidance systems were targeting at reducing travel time of the users by 4%. Under the system of this invention, the travel times would all be known and independent of congestion once a vehicle had entered the system. Under the current system, the dynamic delays can change measurably after a vehicle is committed to a specific route. According to the Federal Highway Administration Intelligent Transportation Systems (ITS Field Operational Test), dynamic route guidance systems have not been successful.

Brief Summary Text (133):
There are several systems presented in the Federal Highway Administration Intelligent Transportation Systems (ITS Field Operational Test) for giving traffic information to commuters, called "Advance Traveler Information System" (ATIS). In none of these articles does it discuss the variation in travel time during rush hour for example, from one day to the next. The variability in this travel time would have to be significant to justify such a system. Naturally, a system of this type would be unnecessary in situations where the instant invention has been deployed. The single most important cause of variability from day to day is traffic incidents such as accidents, which are eliminated or at least substantially reduced by the instant invention. One of the conclusions in a study published in the "Federal Highway Administration Intelligent Transportation Systems (ITS Field Operational Test)" entitled "Direct Information Radio Using Experimental Communication Technologies" was that drivers did not feel that the system was a significant advance over commercial radio traffic information. They did think the system was an improvement over television traffic information and changeable message signs. The drivers surveyed on average having changed their route only one time in the eight week test period due to information they received from the system.

Brief Summary Text (134):
i. Weather and Road Condition Monitoring

Brief Summary Text (135):
A paper by Miyata, Yasuhiro and Otomo, Katsuya, Kato, Haijime, Imacho, Nobuhiro, Murata, Shigeo, entitled "Development of Road Icing Prediction System" describes a method of predicting road icing conditions several hours in advance based on an optical fiber sensor laid underneath the road and the weather forecast data of that area.

Brief Summary Text (136):
There is likely a better way of determining ice on the road than described in this paper. The reflection of an infrared wave off the road varies significantly depending on whether there is ice on the road or snow, or the road is wet or dry. An unsupervised neural network could be a better solution. The system of this paper measures the road surface temperature, air temperature and solar radiation. A combination of active and passive infrared would probably be sufficient. Perhaps, a specially designed reflective surface could be used on the road surface in an area where it is not going to be affected by traffic.

Brief Summary Text (137):
What this paper shows is that if the proper algorithm is used, the actual road temperature can be predicted without the need to measure the road surface temperature. This implies that icing conditions can be predicted and the sensors would not be necessary. Perhaps, a neural network algorithm that monitors a particular section of road and compares it to the forecasted data would be all that is required. In other words, given certain meteorological data, the neural network ought to be able to determine the probability of icing. What is needed, therefore, is to pick a section of roadway and monitor that roadway with a state-owned vehicle throughout the time period when icing is likely to occur and determine if icing has occurred and compare that with the meteorological data using a neural network that is adapted for each section of road.

Brief Summary Text (138):
j. Vehicle to Vehicle Communication

Brief Summary Text (141):
The DGPS correction information can be broadcast over the radio data system (RDS) via FM transmitters for land use. A company called Differential Correction, Inc. has come up with a technique to transmit this DGPS information on the RDS channel. This technique has been used in Europe since 1994 and, in particular, Sweden has launched a nationwide DPGS service via the RDS (see, Sjoberg, Lars, "A `1 Meter` Satellite Based Navigation Solutions for the Mobile Environment That Already Are Available Throughout Europe"). This system has the potential of providing accuracies on the premium service of between about 1 and 2 meters. A 1 meter accuracy, coupled with the carrier phase system to be described below, provides an accuracy substantially better than about 1

meter as preferred in the Road to Zero Fatalities (RtZF) system of this invention.

Brief Summary Text (144):
In Choi, Jong and Kim, Hoi, "An Interim Report: Building A Wireless Internet-Based Traveler's Information System As A Replacement Of Car Navigation Systems", a system of showing congestion at intersections is broadcast to the vehicle through the Internet. The use of satellites is disclosed as well as VCS system.

Brief Summary Text (146):
A paper by Sheu, Dennis, Liaw, Jeff and Oshizawa, Al, entitled "A Communication System For In-Vehicle Navigation System" provides another description of the use of the Internet for real traffic information. However, the author (unnecessarily) complicates matters by using push technology which isn't absolutely necessary and with the belief that the Internet connection to a particular vehicle to allow all vehicles to communicate, would have to be stopped which, of course, is not the case. For example, consider the ghome network where everyone on the network is connected all the time.

Brief Summary Text (147):
A paper by, Rick Schuman entitled "Progress Towards Implementing Interoperable DSRC Systems In North America" describes the standards for dedicated short-range communications (DSRC). DSRC could be used for inter-vehicle communications, however, its range according to the ITS proposal to the Federal Government would be limited to about 90 meters. Also, there may be a problem with interference from toll collection systems, etc. According to this reference, however, "it is likely that any widespread deployment of intersection collision avoidance or automated highways would utilize DSRC". Ultra wide band communication systems, on the other hand, are a viable alternative to DSRC as explained below. The DSRC physical layer uses microwaves in the 902 to 928 megahertz band. However, ITS America submitted a petition to the FCC seeking to use the 5.85 to 5.925 gigahertz band for DSRC applications.

Brief Summary Text (153):
Consider placing a requirement that all vehicles have passive transponders such as RFID tags. This could be part of the registration system for the vehicle and, in fact, could even be part of the license plate. This is somewhat disclosed in a paper by Shladover, Steven entitled "Cooperative Advanced Vehicle Control and Safety Systems (AVCSS)". AVCSS sensors will make it easy to detect the presence, location and identity of all other vehicles in their vicinity. Passive radio frequency transponders are disclosed. The use of differential GPS with accuracies as good as about two (2) centimeters, coupled with an inertial guidance system, is disclosed, as is the ability of vehicles to communicate their locations to other vehicles. It discloses the use of accurate maps, but not of lateral vehicle control using these maps. It is obvious from reading this paper that the author did not contemplate the safety system aspects of using accurate maps and accurate GPS. In fact, the author stresses the importance of cooperation between various government levels and agencies and the private sector in order to make AVCSS feasible. "Automotive suppliers cannot sell infrastructure-dependent systems to their customers until the very large majority of the infrastructure is suitable equipped."

Brief Summary Text (165):
The vehicle and road properties must be known prior to the danger or else it is too late. In Phase One the vehicle inertial properties will be determined by monitoring its response to known road inputs.

Brief Summary Text (166):
The system senses when driver goes off the road or commits other infractions and then tests driver response by turning on the hazard lights which the driver must turn off, for example.

Brief Summary Text (175):
Historical road data and weather prediction plus roadway sensors and probes will provide this service in Phase One.

Brief Summary Text (178):
This paper further goes into considerable discussion on various means of communication between a vehicle and other vehicles as well as the infrastructure. However, no

recommendations are made for vehicle-to-vehicle communication technologies.

Brief Summary Text (179):
The above references, among other things, demonstrate that there are numerous methods and future enhancements planned that will provide centimeter level accuracy to an RtZF equipped vehicle. There are many alternative paths that can be taken but which ever one is chosen the result is clear that such accuracies are within the start of the art today.

Brief Summary Text (182):
Additionally, no prior art system has successfully used the GPS navigational system, or an augmented DGPS to locate a vehicle on a roadway with sufficient accuracy that that information can be used to prevent the equipped vehicle from leaving the roadway or striking another similarly equipped vehicle.

Brief Summary Text (184):
The RtZF.TM. system of this invention also contemplates a different kind of interrogating system. It is based on scanning infrared laser radar with range gating. This system, when used in conjunction with accurate maps, will permit a precise imaging of an object on the road in front of the vehicle, for example, permitting it to be identified (using neural networks) and its location, velocity and the probability of a collision to be determined.

Brief Summary Text (188):
It is an object of the present invention to provide a new and improved method and arrangement for mapping a road.

Brief Summary Text (189):
It is another object of the present invention to provide a new and improved method and arrangement for mapping a road quickly and more precisely than possible using prior art systems.

Brief Summary Text (190):
In order to achieve these objects, an arrangement for attaching to a vehicle to enable mapping of a road during travel of the vehicle comprises a first data acquisition module adapted to be arranged on a first side of the vehicle and a second data acquisition module adapted to be arranged on a second side of the vehicle. Each module comprises a GPS receiver and an antenna for enabling a determination of the position of the vehicle to be obtained and a linear camera adapted to provide one-dimensional images of an area on a respective one of the first and second sides of the vehicle. The linear cameras provide images of a vertical plane perpendicular to the road such that a view of the road in a direction perpendicular to the road is obtained and information about the road is obtainable from that view. A processor unit is coupled to the modules and forms a map database of the road by correlating the position of the vehicle on the road and the information about the road. The processor unit can be resident in the vehicle or data can be obtained and stored in a memory unit in the vehicle and the map database formed later from the stored data.

Brief Summary Text (191):
The linear cameras may be linear CCD, CMOS and other light sensitive arrays. The light cameras may comprise a lens for providing a field of view from an approximate center of the vehicle to the horizon whereby the linear cameras are thus adapted to record one-dimensional pictures covering the entire road starting with approximately the center of a lane in which the vehicle travels and extending out to the horizon.

Brief Summary Text (192):
Each module can also include a scanning laser radar adapted to transmit waves downward in a plane perpendicular to the road and receive reflected radar waves to thereby provide information about distance between the laser radar and the ground which constitutes information about the road. The laser radar may be coordinated or synchronized with the linear camera of its module to cover a common field of view. The laser radars may be pulse-modulated or tone-modulated. In one implementation, laser radars are used with the linear cameras being an optional enhancement.

Brief Summary Text (193):

Each module can also comprise a video camera adapted to provide images of an area in front of the vehicle whereby images of an environment of the road including traffic signs and other informational displays are obtained and provide information about the road. Such information is used to form the map database. The video cameras may be color video cameras, high-speed video cameras, wide angle cameras, telescopic cameras, black and white video cameras and infrared cameras. Artificial illumination devices can be incorporated into or with the modules to provide artificial illumination at least when an absence of sufficient natural illumination for obtaining images from the video cameras is detected. In this regard, a laser scanner may be adapted to illuminate a particular part of the area in front of the vehicle with a bright spot. A scanning laser rangefinder can be arranged in connection with at least one of the video cameras for determining the distance to particular objects in the images obtained by that video camera whereby the distance constitutes information about the road which is used to form the map database.

Brief Summary Text (194):
A method for mapping a road entails arranging a first data acquisition module on a first side of the vehicle, arranging a second data acquisition module on a second side of the vehicle, each module comprising a GPS receiver and an antenna and a linear camera oriented to provide one dimensional images in a vertical plane of an area on a respective one of the first and second sides of the vehicle, operating the vehicle on the road while continually obtaining the position of the vehicle using the GPS receiver and antenna and obtaining images from the linear cameras of vertical planes perpendicular to the road and forming a map database of the road by correlating the position of the vehicle on the road and information about the road obtained from the images from the linear cameras. The aspects of the arrangements described above can be incorporated into the mapping method.

Brief Summary Text (195):
Another method for mapping a road comprises (he steps of arranging a first data acquisition module on a first side of the vehicle, arranging a second data acquisition module on a second side of the vehicle, each module comprising a GPS receiver and an antenna and a scanning laser radar oriented to transmit waves downward in a plane perpendicular to the road and receive reflected radar waves, operating the vehicle on the road while continually obtaining the position of the vehicle using the GPS receiver and antenna and obtaining information about the distance between the laser radars and the ground by transmitting and receiving radar waves and forming a map database of the road by correlating the position of the vehicle on the road and the information about distance between the laser radars and the ground. The aspects of the arrangements described above can be incorporated into this mapping method.

Brief Summary Text (196):
Another aspect of the invention is a computer controlled vehicle and obstacle location system and method which includes the steps of receiving continuously from a network of satellites on a first communication link at one of a plurality of vehicles, GPS ranging signals for initially accurately determining, in conjunction with centimeter accurate maps, the host vehicle's position on a roadway on a surface of the earth; receiving continuously at the host vehicle on a second communication link from a station or satellite, DGPS auxiliary range correction signals for correcting propagation delay errors in the GPS ranging signals; determining continuously at the host vehicle from the GPS, DGPS, and accurate map database signals host vehicle's position on the surface of the earth with centimeter accuracy; communicating the host vehicle's position to another one of the plurality of vehicles, and receiving at the host vehicle, location information from at least one of a plurality of other vehicles; determining whether the other vehicle represents a collision threat to the host vehicle based on its position relative to the roadway and the host vehicle and generating a warning or vehicle control signal response to control the vehicles motion laterally or longitudinally to prevent a collision with the other vehicle.

Brief Summary Text (199):
The first phase of implementation of this invention can be practiced with only minor retrofit additions to the vehicle. These include the addition of a differential GPS system and an accurate map database. In this first phase, the driver will only be warned when he or she is about to depart from the road surface. During the second phase of practicing this invention, the system will be augmented with a system that

will prevent the operator from leaving the assigned corridor and in particular leaving the road at high speed. In further phases of the implementation of this invention, additional systems will be integrated which will scan the roadway and act to prevent accidents with vehicles that do not have the system installed. Also communication systems will be added to permit the subject vehicle to communicate its position, velocity, etc., to other nearby vehicles which are also equipped with a system.

Brief Summary Text (200):
A primary preferred embodiment of the system, therefore, is to equip a vehicle with a DGPS system, a laser gyro or other inertial guidance system, vehicle steering, throttle and brake control apparatus, a sub-meter accurate digital map system with the relevant maps (or ability to access the relevant maps), a scanning pulsed infrared laser radar, a system for sensing or receiving signals from a highway-based precise position determination system, and communications systems for (1) sending and receiving data from similarly equipped vehicles, (2) receiving updated maps and map status information, and (3) receiving weather and road condition information. A preferred embodiment for the infrastructure enhancements includes a DGPS system, a micropower impulse radar (MIR), Radio Frequency Identification (RFID) based or equivalent precise position determining system and local weather and road condition determination and transmission system.

Brief Summary Text (201):
This invention is thus a method and apparatus for preventing vehicle accidents. A vehicle is equipped with a differential GPS (DGPS) navigational system as well as an inertial navigation subsystem. Part of the system can be an array of infrastructure stations that permit the vehicle to exactly determine its position at various points along its path. Such stations would typically be located at interals such as every 50 miles along the roadway, or more or less frequently depending on requirements as described below. These stations permit the vehicle to become its own DGPS station and thus to correct for the GPS errors and to set the position of the vehicle based initial guidance system. It also provides sufficient information for the vehicle to use the carrier frequency to determine its absolute position to within a few centimeters or better for as long as satellite locks are maintained. Data is also available to the vehicle that provides information as to the edges of the roadway, and edges of the lanes of the roadway, at the location of the vehicle so that the vehicle control system can continuously determine its location relative to the roadway edges and/or lane edges. In the initial implementation, the operator operates his or her vehicle and is unaware of the presence of the accident avoidance system. If, however, the operator falls asleep go or for some other reason attempts to drive off the roadway at high speed, the system will detect that the vehicle is approaching an edge of the roadway and will either sound an alarm or prevent the vehicle from leaving the roadway when doing so would lead to an accident. In some cases, the system will automatically reduce the speed of the vehicle and stop it on the shoulder of the roadway.

Brief Summary Text (205):
A third improvement comprises the addition of software to the system that permits vehicles on specially designated vehicle corridors for the operator to relinquish control of the vehicle to the vehicle-based system, and perhaps to a roadway computer system. This then permits vehicles to travel at high speeds in a close packed formation thereby substantially increasing the flow rate of vehicles on a given roadway. Naturally, in order to enter the designated corridors, a vehicle would be required to be equipped with the RtZF. Similarly, this then provides an incentive to vehicle owners to have their vehicles so equipped so that they can enter the controlled corridors and thereby shorten their travel time.

Brief Summary Text (206):
Prior art systems require expensive modifications to highways to permit such controlled high speed close packed travel. Such modifications also require a substantial infrastructure to support the system. The RtZF of the present invention, in its simplest form, does not require any modification to the roadway but rather relies primarily on the GPS or similar satellite system. The edge and lane boundary information is either present within the vehicle RtZF memory or transmitted to the vehicle as it travels along the road. The permitted speed of travel is also communicated to the vehicles on the restricted corridor and thus each vehicle travels

at the appointed speed. Since each vehicle knows the location of all other vehicles in the vicinity, should one vehicle slow down, due to an engine malfunction, for example, appropriate action can be taken to avoid an accident. Vehicles do not need to travel in groups as suggested and required by some prior art systems. Rather, each vehicle may independently enter the corridor and travel at the system defined speed until it leaves, which may entail notifying the system of a destination.

Brief Summary Text (207):
Another improvement involves the transmission of additional data concerning weather conditions, traffic accidents etc. to the equipped vehicle so that the speed of that vehicle can be limited to a safe speed depending on road conditions, for example. If moisture is present on the roadway and the temperature is dropping to the point that ice might be building up on the road surface, the vehicle can be notified by the roadway information system and prevented from traveling at an unsafe speed.

Brief Summary Text (208):
Other objectives and advantages of the RtZF system of this invention disclosed herein include: 1. To provide a system based partially on the global positioning system (GPS) or equivalent that permits an onboard electronic system to determine the position of a vehicle with an accuracy of 1 meter or better. 2. To provide a system which permits an onboard electronic system to determine the position of the edges and/or lane boundaries of a roadway with an accuracy of 1 meter or less in the vicinity of the vehicle. 3. To provide a system which permits an onboard vehicle electronic system to determine the position of the edges and/or lane boundaries of a roadway relative to the vehicle with an accuracy of less than about 10 centimeters. 4. To provide a stem that substantially reduces the incidence of single vehicle accidents caused by the vehicle inappropriately leaving the roadway at high speed. 5. To provide a system which does not require modification to a roadway which permits high speed controlled travel of vehicles on the roadway thereby increasing the vehicle flow rate on congested roads. 6. To provide a collision avoidance system comprising a sensing system responsive to the presence of at least one other vehicle in the vicinity of the equipped vehicle and means to determine the location of the other vehicle relative to the lane boundaries of the roadway and thereby determine if the other vehicle has strayed from its proper position on the highway thereby increasing the risk of a collision, and taking appropriate action to reduce that risk. 7. To provide a means whereby vehicles near each other can communicate their position and/or their velocity to each other and thereby reduce the risk of a collision. 8. To provide a means for accurate maps of a roadway to be transmitted to a vehicle on the roadway. 9. To provide a means for weather, road condition and/or similar information can be communicated to a vehicle traveling on a roadway plus means within the vehicle for using that information to reduce the risk of an accident. 10. To provide a means and apparatus for a vehicle to precisely know its location at certain positions on a road by passing through or over an infrastructure based local subsystem thereby permitting the vehicle electronic systems to self correct for the satellite errors making the vehicle for a brief time a DGPS station. 11. To utilize government operated navigation aid systems such as the WAAS and LARS as well as other available or to become available systems to achieve sub-meter vehicle location accuracies. 12. To utilize the OpenGIS.TM. map database structure so as to promote open systems for accurate maps for the RtZF.TM. system. 13. To eliminate intersection collisions caused by a driver running a red light or stop sign. 14. To eliminate intersection collisions caused by a driver executing a turn into oncoming traffic.

Brief Summary Text (210):
It is important to understand that this is a process control problem. The process is designed so that it should not fail and thus all accidents should be eliminated. Events that are troublesome to the system include a deer running in front of the vehicle, a box falling off of a truck, a rock rolling onto the roadway and a catastrophic failure of a vehicle. Continuous improvement to the process is thus required before these events are substantially eliminated. Each individual driver and vehicle control system is part of the system and upon observing that such an event has occurred he or she should have the option of stopping the process to prevent or mitigate an emergency. All equipped vehicles therefore have the capability of communicating that the process is stopped and therefore that the vehicle speed, for example, should be substantially reduced until the vehicle has passed the troubled spot or until the problem ceases to exist. In other words, each driver is part of the

process.

Brief Summary Text (212):
This invention is a method and apparatus for eliminating accidents by accurately determining the position of a vehicle, accurately knowing the position of the road and communicating between vehicles and between the vehicle and the infrastructure supporting travel. People get into accidents when they go too fast for the conditions and when they get out of their corridor. This invention eliminates these and other causes of accidents. In multilane highways, this system prevents people from shifting lanes if there are other vehicles in the blind spot, thus, solving the blind spot problem. The vehicle would always be traveling down a corridor where the width of the corridor may be a lane or the entire road width or something in between depending on road conditions and the presence of other vehicles.

Brief Summary Text (213):
The invention is implemented through the use of both an inertial navigation system (INS) and a DGPS, in some cases with carrier frequency enhancement. Due to the fact that the signals from at least four GPS or GLONASS satellites are not always available and to errors caused by multiple path reception from a given satellite, the DGPS systems cannot be totally relied upon. Therefore the INS is a critical part of the system. This will improve as more satellites are launched and additional ground stations are added. It will also significantly improve when the WAAS and LAAS systems are implemented and refined to work with land vehicles as well as airplanes.

Brief Summary Paragraph Table (1):
(1) Rear-End Collision Avoidance Gen. 0 Gen. I Gen. II (1a) Monitors motion and location of other LHTS vehicles and other objects in front of vehicle. (1b) Advises the driver of imminent rear-end LHTS crashes. (1c) Provides automatic braking. LHTS

Brief Summary Paragraph Table (2):
(2) Road-Departure Collision Avoidance Gen. 0 Gen. I Gen. II (2a) Monitors lane position of the vehicle LHTS and motion relative to edge of road. (2b) Monitors vehicle speed relative to road LHTS geometry and road conditions. (2c) Advises the driver of imminent LHTS unintentional road departure. (2d) Provides cooperative communication LHTS with highway infrastructure to automatically provide safe speeds for upcoming road geometry and conditions.

Brief Summary Paragraph Table (3):
Gen. 0 Gen. I Gen. II (3) Lane-Change and Merge Collision Avoidance (3a) Monitors lane position of the vehicle. LHTS (3b) Monitors the relative speed and lane po- LHTS sition of vehicles (including motorcycles) beside and to the rear of the vehicle. (3c) Advises the driver during the decision LHTS phase (turn signal activated) of a lane-change maneuver of the potential for a collision. (3d) Advises the driver during the action LHTS phase (steering input) of a lane-change maneuver of an imminent collision. (3e) Advises the driver during the action LHTS phase (steering input) of an entry or exit maneuver of an imminent collision. (4) Intersection Collision Avoidance (4a) Monitors vehicle position relative to LHTS intersection geometry. (4b) Monitors relative speed and position of LHTS other vehicles. (4c) Advises the driver of appropriate action LHTS to avoid a violation of right-of-way at the intersection. (4d) Advises the driver of appropriate action LHTS to avoid an impending collision at the intersection. (4e) Determines the intent of other vehicles LHTS in the intersection to turn, slow down, stop, or violate the right-of-way. (5) Railroad Crossing Collision Avoidance (5a) Monitors vehicle position relative to LHTS railroad crossing. (5b) Monitors vehicle position and speed LHTS relative to position and speed of a train (5c) Advises the driver of appropriate action LHTS to avoid an impending collision at railroad crossing. (6) Vision Enhancement (6a) Provides an enhanced view of pedes- LHTS trians and roadside features with an infrared system. (6b) Provides an enhanced view of the NA environment using a UV system. (7) Location-Specific Alert and Warning (7a) Provides warning information by LHTS integrating vehicle speed with knowledge of road geometry. (7b) Provides warning information by LHTS integrating environmental conditions with road surface conditions. (7c) Provides warning information on road LHTS geometry by integrating vehicle speed, road conditions, and road geometry. (7d) Provides warning information on LHTS upcoming traffic signs and signalized intersections.' (7e) Provides warnings that replicate one or LHTS more types of road signs in complex or hazardous highway locations. (8) Automatic Collision Notification

(8a) Automatically transmits position/loca- LHTS tion of vehicle, when involved in a collision, using PSAP. (8b) Automatically provides crash severity LHTS information from vehicle to PSAP. (8c) Integrates with manually activated LHTS systems for requesting roadside assistance.

Brief Summary Paragraph Table (5):
(10) Navigation/Routing Gen. 0 Gen. I Gen. II (10a) Provides location information to the LHTS driver. (10b) Provides route guidance information to LHTS the driver. (10c) Provides road geometry data to CAS. LHTS (10d) Provides location data to CAS. LHTS (10e) Displays only the traffic information LHTS that is applicable to vehicle location and route. (10f) Provides optimal routing based on LHTS driver preferences. (10g) Uses real-time traffic information in LHTS calculations of optimal routes.

Brief Summary Paragraph Table (6):
(11) Real-Time Traffic and Traveler Information Gen. 0 Gen. I Gen. II (11a) Accesses in-vehicle databases to LHTS determine vehicle location and route guid- ance instructions. (11b) Receives travel-related information from the infrastructure (roadside or wide- area transmissions) to include: (11b-i) Motorist and traveler services LHTS information. (11b-ii) Safety and advisory information. LHTS (11b-iii) Real-time updates on congestion; LHTS work zones; environmental and road surface conditions. (11c) Provides an integrated approach to the LHTS presentation of information to the driver for safety warnings and other task-related advisories. (11d) Provides the capability of reacting to LHTS information on environmental and road conditions (augments static database). (12) Driver Comfort and Convenience NA

Brief Summary Paragraph Table (13):
(19) Obstacle/Pedestrian Detection Gen. 0 Gen. I Gen. II (19a) Warns the driver when pedestrians, LHTS vehicles, or obstacles are in close proximity to the driver's intended path using onboard sensors. (19b) Warns the driver when pedestrians, NA vehicles, or obstacles are in close proximity to the driver's intended path using infra- structure-based sensors.

Drawing Description Text (3):
FIG. 1 illustrates the GPS satellite system with the 24 satellites revolving around the earth.

Drawing Description Text (4):
FIG. 2 illustrates four GPS satellites transmitting position information to a vehicle and to a base station which in turn transmits the differential correction signal to the vehicle.

Drawing Description Text (5):
FIG. 3 illustrates a WADGPS system with four GPS satellites transmitting position information to a vehicle and to a base station which in turn transmits the differential correction signal to the vehicle.

Drawing Description Text (6):
FIG. 4 is a logic diagram showing the combination of the GPS system and an inertial navigation system.

Drawing Description Text (14):
FIG. 12a is a flow chart of the method in accordance with the invention for preventing run off the road accidents.

Drawing Description Text (17):
FIG. 13 illustrates an intersection with stop signs on the lesser road where there is a potential for a front to side impact and a rear end impact.

Drawing Description Text (20):
FIG. 16A is a side view of a vehicle equipped with a road-mapping arrangement in accordance with the invention.

Drawing Description Text (21):
FIG. 16B is a front perspective view of a vehicle equipped with the road-mapping arrangement in accordance with the invention.

Drawing Description Text (24):
FIG. 18 shows the view of a road from the video cameras in both of the data acquisition modules.

Detailed Description Text (5):
For example, the present inventions make use of GPS satellite location technology, including the use of MIR or RFID triads, to derive kinematic vehicle location and motion trajectory parameters for use in a vehicle collision avoidance system and method. The inventions described herein are not to be limited to the specific GPS devices or PPS devices disclosed in the preferred embodiments, but rather, are intended to be used with any and all such applicable satellite location devices, systems and methods, as long as such devices, systems and methods generate input signals that can be analyzed by a computer to accurately quantify vehicle location and kinematic motion parameters in real time. Thus, the GPS devices and methods shown and referenced generally throughout this disclosure, unless specifically noted, are intended to represent any and all devices appropriate to determine such location and kinematic motion parameters.

Detailed Description Text (10):
The above and other objects are achieved in the present invention which provides motor vehicle collision avoidance, warning and control systems and methods using GPS satellite location systems augmented with precise positioning systems to provide centimeter location accuracy, and to derive vehicle attitude and position coordinates and vehicle kinematic tracking information. GPS location and computing systems being integrated with vehicle video scanning, radar, laser radar, and on board speedometer and/or accelerometers and gyroscopes to provide accurate vehicle location information together with information concerning hazards and/or objects that represent impending collision situations for each vehicle. Advanced image processing techniques are used to quantify video information signals and to derive vehicle warning and control signals based upon detected hazards.

Detailed Description Text (11):
Outputs from multiple sensors as described above are used in onboard vehicle neural network and neural-fuzzy system computing algorithms to derive optimum vehicle warning and control signals designed to avoid vehicle collisions with other vehicles or with other objects or hazards that may be present on given roadways. In a preferred embodiment, neural fuzzy control algorithms are used to develop coordinated braking, acceleration and steering control signals to control individual vehicles in an optimal manner to avoid or minimize the effects of potential collisions. Video, radar, laser radar and GPS position and trajectory information are made available to each individual vehicle describing the movement of that vehicle and other vehicles in the immediate vicinity of that vehicle.

Detailed Description Text (13):
Description of GPS System

Detailed Description Text (14):
Background of GPS

Detailed Description Text (15):
Referring to FIG. 1, the presently implemented Global Positioning System with its constellation of 24 satellites 2 is truly revolutionizing navigation throughout the world. The satellites orbit the Earth in six orbits 4. However, in order: to reach its full potential for navigation, GPS needs to be augmented both to improve accuracy and to reduce the time needed to inform a vehicle driver of a malfunction of a GPS satellite, the so-called integrity problem.

Detailed Description Text (16):
The Global Positioning System (GPS) is a satellite-based navigation and time transfer system developed by the U.S. Department of Defense. GPS serves marine airborne and terrestrial users, both military and civilian. Specifically, GPS includes the Standard Positioning Service (SPS) that provides civilian users with 100 meter accuracy as to the location or position of the user. It also serves military users with the Precise Positioning Service that provides 20-meter accuracy for the user. Both of these

services are available worldwide with no requirement for any local equipment.

Detailed Description Text (17):
Differential operation of GPS is used to improve the accuracy and integrity of GPS. Differential GPS places one or more high quality GPS receivers at known surveyed locations to monitor the received GPS signals. This reference station(s) estimates the slowly varying components of the satellite range measurements, and forms a correction for each GPS satellite in view. The correction is broadcast to all DGPS users within the coverage area of the broadcast facilities.

Detailed Description Text (20):
"The new OMNISTAR Model 6300A offers unprecedented versatility for portable, real-time, DGPS positioning. It can improve the accuracy of a GPS receiver by as much as 100 times. If your product or service needs precise positioning information. then chances are good that OMNISTAR can supply that need; and at a reasonable cost.

Detailed Description Text (22):
"OMNISTAR is a Differential GPS (DGPS) System. It is capable of improving regular GPS to sub-meter accuracy. GPS computes a user's position by measuring ranges (actually, pseudoranges; which are ranges that are calculated by an iterative process) to three or more GPS satellites simultaneously. The Department of Defense (DOD) is intentionally limiting the accuracy of the calculation by continuously changing the onboard clock on the satellites. This process is called Selective Availability, or "SA". This appears as a continuous variation in the user's position. Using GPS in an uncorrected (stand-alone) mode, a user's calculated position mill continuously move around the true position in a near-random pattern. The indicated position may move out as far as 100 meters from the true position. The randomness makes it impossible to predict. If a user samples the position data over a long period of time, such as 24 hours, the average or mean will likely be within a meter of the true position. In statistical terms, the standard deviation will be approximately 15 to 20 meters in each horizontal coordinate.

Detailed Description Text (23):
"A DGPS System generates corrections for SA and other errors. This is accomplished by the use of one or more GPS "Base Stations" that measure the errors in the GPS system and generates corrections. A "real-time" DGPS System not only generates the corrections, but provides some methodology for getting those corrections to users as quickly as possible. This always involves some type of radio transmission system. They may use microwave systems for short ranges, low frequencies for medium ranges and geostationary satellites for coverage of entire continents.

Detailed Description Text (24):
"The method of generating corrections is similar in most DGPS systems. A GPS base station tracks all GPS Satellites that are in view at its location. The internal processor knows the precise surveyed location of the base station antenna, and it can calculate the location in space of all GPS satellites at any time by using the epheremis that is a part of the normal broadcast message from all GPS satellites. From these two pieces of information, an expected range to each satellite can be computed at any time. The difference between that computed range and the measured range is the range error. If that information can quickly be transmitted to other nearby users, they can use those values as corrections to their own measured GPS ranges to the same satellites. The key word is "quickly", because of the rapid change in the SA errors. In most radio systems, bandwidth is a finite limitation which dictates how much data can be sent in a given time period. That limitation can be eased somewhat by having the GPS base station software calculate the rate of change of the errors and add that information as part of the correction message. That term is called the range rate value and it is calculated and sent along with the range correction term. The range correction is an absolute value, in meters, for a given satellite at a given time of day. The range rate term is the rate that correction is changing, in meters per second. That allows GPS user sets to continue to use the "correction, plus the rate-of-change" for some period of time while it's waiting for a new message. The length of time you can continue to use that data without an update depends on how well the range rate was estimated. In practice, it appears that OMNISTAR would allow about 12 seconds before the DGPS error would cause a one meter position error. In other words, the "age of data" can be up to 12 seconds before the error from that term would

cause a one meter position error. OMNISTAR transmits a new correction message every two and one/half seconds, so even if an occasional message is missed, the user's "age of data" is still well below 12 seconds.

Detailed Description Text (27):
"The methodology developed by John E. Chance & Assoc. of using multiple GPS base stations in a user's solution and reducing errors due to the GPS signal traveling through the atmosphere, met the second objective. It was the first widespread use of a "Wide Area DGPS Solution". It is able to use data from a relatively small number of base stations and provide consistent accuracy over extreme distances. A unique method of solving for atmospheric delays and weighting of distant base stations, achieves sub-meter capability over the entire coverage area--regardless of the user's proximity to any base station. This achieves a truly nationwide system with consistent characteristics. A user can take the equipment anywhere within the coverage area and get consistent results, without any intervention or intimate knowledge of GPS or DGPS.

Detailed Description Text (28):
"The units being sold today are sufficiently portable that they can used in a backpack. They can include an internal GPS engine (optional) that will provide a complete solution in a single system package. All that is needed is a data collector or notebook computer for display and storage of corrected GPS data.

Detailed Description Text (30):
"The OMNISTAR Network consists of ten permanent base stations that are scattered throughout the Continental US, plus one in Mexico. These stations track all GPS Satellites above 5 degrees elevation and compute corrections every 600 milliseconds. The corrections are in the form of an industry standard message format called RTCM-104, Version II. The corrections are sent to the OMMSTAR Network Control Center in Houston via lease lines, with a dial back-up. At the NCC these messages are checked, compressed, and formed into a packet for transmission up to our satellite transponder. This occurs approximately every 2 to 3 seconds. A packet will contain the latest data from each of the 11 base stations.

Detailed Description Text (32):
"Fortunately, this requirement of giving the user's OMNISTAR an approximate location is easily solved. If OMNISTAR is purchased with the optional internal GPS receiver installed, the problem is taken care of automatically by using the position output of the GPS receiver as the approximation. It is wired internally to do exactly that. An alternate method--when the internal GPS receiver is not present--is to use the user's external GPS receiver for this function. In that case, the user's receiver must have an output message in one of the approved formats (NMEA) and protocols that OMNISTAR can recognize.

Detailed Description Text (33):
"That output can be connected back to the OMNISTAR set by using the same cable that normally supplies the RTCM-104 from OMNISTAR to the user's GPS receiver. This method works perfectly well when all the requirements on format and protocol are met. There is a third method, where a user uses a notebook computer to type in an estimated location into the, OMNISTAR user set. Any location entered by this method is preserved--with an internal battery--until it is changed. This method works fine where the user does not intend to go more than 50-100 miles from some central location.

Detailed Description Text (34):
"After the OMNISTAR processor has taken care of the atmospheric corrections, it then uses it's location versus the eleven base station locations, in an inverse distance-weighted least-squares solution. The output of that least-squares calculation is a synthesized RTCM-104 Correction Message that is optimized for the user's location. It is always optimized for the user's location that is input from the user's GPS receiver or as an approximation that is typed in from a notebook computer. This technique is called the "Virtual Base Station Solution". It is this technique that enables the OMNISTAR user to operate independently and consistently over the entire coverage area without regard to where he is in relation to our base stations. As far as we have determined, users are obtaining the predicted accuracy over the entire area."

Detailed Description Text (36):
GLONASS is a Russian system similar to GPS. This system provides accuracy that is better than GPS with SA on and not as good as GPS with SA off. It is expected that SA will be removed before the system described herein is implemented.

Detailed Description Text (37):
The Projected Position Accuracy of GPS and GLONASS, Based on the Current Performance is:

Detailed Description Text (38):
The system described here will achieve a higher accuracy than reported in the above table due to the combination of the inertial guidance system that permits accurate changes in position to be determined and through multiple GPS readings. In other words, the calculated position will converge to the real position over its time. The addition of DGPS will provide an accuracy improvement of at least a factor of 10, which, with the addition of a sufficient number of DGPS stations in some cases is sufficient without the use of the carrier frequency correction. A further refinement where the vehicle becomes its own DGPS station through the placement of infrastructure stations at appropriate locations on roadways will further significantly enhance the system accuracy to the required level.

Detailed Description Text (41):
An important feature of DGPS is that the errors from the GPS satellites change slowly with time and therefore, only the corrections need be sent to the user from time to time. Using reference receivers separated by 25-120 km, accuracies from 10 cm to 1 m are achievable using local area DGPS which is marginal for RtZF. Alternately, through the placement of appropriate infrastructure transmitters as described below even better accuracies are obtainable.

Detailed Description Text (42):
A type of wide area DGPS (WADGPS) system has been developed spans the entire US continent which provides position RMS accuracy to better than 50 cm. This system is described in the Bertiger, et al, "A Prototype Real-Time Wide Area Differential GPS System," Proceedings of the National Technical Meeting, Navigation and Positioning in the Information Age, Institute of Navigation, Jan. 14-16, 1997 pp. 645-655. A RMS error of 50 cm would be marginally accurate for RtZF. Many of the teachings of this invention especially if the road edge and lane location error were much less which could be accomplished using more accurate surveying equipment. The OmniSTAR system is another WADGPS system that claims 6 cm (1.sigma.) accuracy.

Detailed Description Text (46):
Unfortunately, the respective error sources mentioned above rapidly decorrelate as the distances between the reference station and the vehicle increases. Conventional DGPS is the terminology used when the separation distances are sufficiently small that the errors cancel. The terms single-reference and multi-reference DGPS are occasionally used in order to emphasize whether there is a single reference station or whether there are multiple ones. If it is desired to increase the area of coverage and, at the same time, to minimize the number of fixed reference receivers, it becomes necessary to model the spatial and temporal variations of the residual errors. Wide Area Differential GPS (WADGPS) is designed to accomplish this. In addition, funds have now been appropriated for the US Government to deploy a national DGPS system.

Detailed Description Text (50):
The Wide Area Augmentation System (WAAS) is being deployed to replace the Instrument Landing System used at airports across the country. The WAAS system provides an accuracy of from about 1 to 2 meters for the purpose of aircraft landing. If the vertical position of the vehicle is known, as would be in the case of automobiles at a known position on a road, this accuracy can be improved significantly. Thus, for many of the purposes of this invention, the WAAS can be used, to provide accurate positioning information for vehicles on roadways. The accuracy of the WAAS is also enhanced by the fact that there is an atomic clock in every WAAS receiver station that would be available to provide great accuracy using carrier phase data. With this system sub-meter accuracies are possible for some locations.

Detailed Description Text (51):
The WAAS is based on a network of approximately 35 ground reference stations. Signals from GPS satellites are received by aircraft receivers as well as by ground reference stations. Each of these reference stations is precisely surveyed, enabling each to determine any error in the GPS signals being received at its own location. This information is then passed to a wide area master station. The master station calculates correction algorithms and assesses the integrity of the system. This data is then put into a message format and sent to a ground earth station for uplink to a geostationary communications satellite. The corrective information is forwarded to the receiver on board the aircraft, which makes the needed adjustments. The communications satellites also act as additional navigation satellites for the aircraft, thus, providing additional navigation signals for position determination.

Detailed Description Text (52):
This system will not meet all of FAA's requirements. For category III landings, the requirement is 1.6-m vertical and horizontal accuracy. To achieve this, FAA is planning to implement a network of local area differential GPS stations that will provide the information to aircraft. This system is referred to as the Local Area Augmentation System (LAAS).

Detailed Description Text (55):
The Local Area Augmented System (LAAS) is also being deployed in addition to the WAAS system to provide even greater coverage for the areas surrounding major airports. According to Newsletter of the Institute of Navigation, 1997, "the FAA's schedule for (LAAS) for Category II and III precision instrument approaches calls for development of standards by 1998 that will be sufficient to complete a prototype system by 2001. The next step will be to work out standards for an operational system to be fielded in about 2005, that could serve nationwide up to about 200 runways for Cat II-III approaches."

Detailed Description Text (56):
In a country like the United States, which has many airfields, a WAAS can serve a large market and is perhaps most effective for the control of airplane landings. The best way for other countries, with fewer airports, to participate in the emerging field of GPS-based aviation aids may be to build LAAS. In countries with a limited number of airports, LAAS is not very expensive while the costs of building a WAAS to get Category I type accuracy is very expensive. However, with the added benefit of less highway construction and greater automobile safety, the added costs for a WAAS system may well be justified for much of the world.

Detailed Description Text (57):
For the purposes of the RtZF.TM. system, both the WAAS and LAAS would be useful but probably insufficient unless the information is used in a different mathematical system such as used by the OmniSTAR.TM. WADGPS system. Unlike an airplane, there are many places where it might not be possible to receive LAAS and WAAS information or even more importantly the GPS signals themselves with sufficient accuracy and reliability. Initial RtZFT.TM. systems may therefore rely on the WAAS and LAAS but as the system develops more toward the goal of zero fatalities, road based systems which permit a vehicle to pinpoint its location will be preferred. However, there is considerable development ongoing in this field so that all systems are still candidates for use with RtZF.TM. system and the most cost effective will be determined in time.

Detailed Description Text (59):
An extremely accurate form of GPS is Carrier Based Differential GPS. This form of GPS utilizes the 1.575 GHz carrier component of the GPS signal on which the Pseudo Random Number (PRN) code and the data component are superimposed. Current versions of Carrier Based Differential GPS involve generating position determinations based on the measured phase differences at two different antennas, a base station or pseudolite and the vehicle, for the carrier component of a GPS signal. This technique initially requires determining how many integer wave-lengths of the carrier component exist between the two antennas at a particular point in time. This is called integer ambiguity resolution. A number of approaches currently exist for integer ambiguity resolution. Some examples can be found in U.S. Pat. Nos. 5.583,513 and 5,619,212. Such systems can achieve sub-meter accuracies and, in some cases; accuracies of about 1 cm

or less. U.S. Pat. No. 5,477,458 discloses a DGPS system that is accurate to about 5 cm with the base stations located on a radius of about 3000 km. With such a system, very few base stations would be required to cover the continental United States. This system still suffers from the availability of accurate signals at the vehicle regardless of its location on the roadway and the location of surrounding vehicles and objects. Nevertheless, the principle of using the carrier frequency to precisely determine the location of a vehicle can be used with the highway based systems described below to provide extreme location accuracies. Using the PPS system described below where a vehicle becomes its own DGPS system, the carrier phase ambiguity problem also disappears since the number of cycles can be calculated if the precise location is known. There is no ambiguity when the vehicle is at the PPS station and that is maintained as long as the lock on a satellite is not lost for more than a few minutes.

Detailed Description Text (61):
There are other sources of information that can be added to increase the accuracy of position determination, The use of GPS with four satellites provides the three dimension location of the vehicle plus time. Of the dimensions, the vertical is the least accurately known, yet, if the vehicle knows where it is on the roadway, the vertical dimension is not only the least important but it is also already accurately known from the roadmap information plus the inertial guidance system.

Detailed Description Text (62):
Another aid is to provide markers along side the roadway which can be either visual, passive or active transponders, reflectors, or a variety of other technologies, which have the property that as a vehicle passes the marker it can determine the identity of the marker and from a database it can determine the exact location of the marker. If three or more of such markers are placed along side of the roadway, a passing vehicle can determine its exact location by triangulation. Although it may be impractical to initially place such markers along all roadways, it would be reasonable to place them in particularly congested areas or places where it is known that a view of one or more of the GP S satellites is blocked. A variation of this concept will be discussed below.

Detailed Description Text (63):
Although initially it is preferred to use the GPS navigational satellites as the base technology, the invention is not limited thereby and contemplates using all methods by which the location of the vehicle can be accurately determined relative to the earth surface. The location of the roadway boundaries and the location of other vehicles relative to the earth surface are also to be determined and all relevant information used in a control system to substantially reduce and eventually eliminate vehicle accidents. Only time and continued system development will determine the mix of technologies that provide the most cost effective solution. All forms of information and methods of communication to the vehicle are contemplated including direct communication with stationary and moving satellites, communication with fixed earth-based stations using infrared, optical, radar, radio and other segments of the electromagnetic spectrum. Some additional examples follow:

Detailed Description Text (64):
A pseudo-GPS can be delivered from cell phone stations, in place of or in addition to satellites. In fact, the precise location of a cell phone tower need not initially be known. If it monitors the GPS satellites over a sufficiently long time period, the location can be determined as the calculated location statistically converges to the exact location. Thus, every cell phone tower could become an accurate DGPS base station for very little cost. DGPS corrections can be communicated to a vehicle via FM radio via a sub-carrier frequency for example. An infrared or radar transmitter along the highway can transmit road boundary location information. A CD-ROM or other portable mass storage can be used at the beginning of a controlled highway to provide road boundary information to the vehicle. Finally, it is contemplated that eventually a satellite will broadcast periodically, perhaps every five minutes, a table of dates covering the entire CONUS that provides the latest update date of each map segment. If a particular vehicle does not have the latest information for a particular region where it is operating, it will be able to use its cell phone to call and retrieve such road maps perhaps through the Internet. Emergency information would also be handled in a similar manner so that if a tree fell across the highway, for example, all nearby

vehicles would be notified.

Detailed Description Text (66):
It is expected, especially initially, that there will be many holes in the DGPS or GPS and their various implementations that will leave the vehicle without an accurate means of determining its location. The inertial navigation system described below will help in filling these holes but its accuracy is limited to a time period significantly less than an hour and a distance of less than 50 miles before it needs correcting. That may not be sufficient to cover the period between DGPS availability. It is therefore contemplated that the RtZF system will also make use of low cost systems located along the roadways that permit a vehicle to accurately determine its location. One example of such a system would be to use a group of three Micropower Impulse Radar (MIR) units such as developed by Lawrence Livermore Laboratory.

Detailed Description Text (67):
A MIR operates on very low power and periodically transmits a very short spread spectrum radar pulse. The estimated cost of a MIR is less than $10 even in small quantities. If three such MIR transmitters, 151, 152 and 153, as shown in FIG. 11, are placed along the highway and triggered simultaneously or with a known delay, and if a vehicle has an appropriate receiver system, the time of arrival of the pulses can be determined and thus the location of the vehicle relative to the transmitters determined. The exact location of the point where all three pulses arrive simultaneously would be the point that is equidistant from the three transmitters and would be located on the map information. Only three devices are required since only two dimensions need to be determined since it is assumed that the vehicle in on the road and thus the vertical position is known, otherwise four MIRs would be required. Thus it would not even be necessary to have the signals contain identification information since the vehicle would not be so far off in its position determination system to confuse different locations. By this method, the vehicle would know exactly where it was whenever it approached and passed such a triple-MIR installation. The MIR triad PPS or equivalent could also have a GPS receiver and thereby determine its exact location over time as described above for cell phone towers. After the location has been determined, the GPS receiver can be removed. In this case, the MIR triad PPS or equivalent could be placed at will and they could transmit their exact location to the passing vehicles. An alternate method would be to leave the GPS receiver with the PPS time of arrival of the GPS data from each satellite so that the passing vehicles that do not go sufficiently close to the PPS can still get an exact location fix. A similar system using RFID tags is discussed below.

Detailed Description Text (68):
Naturally, several such readings and position determinations can be made with one approach to the MIR installation, the vehicle need not wait until they all arrive simultaneously. Also the system can be designed so that the signals never arrive at the same time and still provide the same accuracy as long as there is a sufficiently accurate clock on board the vehicle. One way at looking at FIG. 11 is that transmitters 151 and 152 fix the lateral position of the vehicle while transmitters 151 and 153 fix the location of the vehicle longitudinally. The three transmitters 151,152,153 need not be along the edges on one lane but could span multiple lanes and they need not be at ground level but could be placed sufficiently in the air so that passing trucks would not block the path of the radiation from an automobile, Particularly in congested areas, it might be desirable to code the pulses and to provide more than three transmitters to further protect against signal blockage or multipath.

Detailed Description Text (69):
The power requirements for the MIR transmitters are sufficiently low that a simple photoelectric cell array can provide sufficient power for most if not all CONUS locations. With this exact location information, the vehicle can become its own DGPS station and can determine the corrections necessary for the GPS. It can also determine the integer ambiguity problem and thereby know the exact number of wave lengths between the vehicle and the satellites or between the vehicle and the MIR station.

Detailed Description Text (72):
Inertial Navigation System

Detailed Description Text (73):
In many cases, especially before the system implementation becomes mature and the complete infrastructure is in place, there will be times when a particular vehicle system is not operational. This could be due to obstructions hiding a clear view of a sufficient number of GPS satellites, such as when a vehicle enters a tunnel. It could also be due to a lack of road boundary information, due to construction or the fact that the road has not been surveyed and the information recorded and made available to the vehicle, or a variety of other causes. It is contemplated, therefore, that each equipped vehicle will contain a warning light that warns the driver when he or she is at a position where the system is not operational. If this occurs on one of the especially designated highway lanes, the vehicle speed will be reduced until the system again becomes operational.

Detailed Description Text (74):
When the system is non-operational for a short distance, the vehicle will still accurately know its position if there is, in addition, one or more laser gyroscopes, micromachined angular rate sensors or equivalent, and one or more accelerometers that together are referred to as an Inertial Navigation System (INS). Generally, such an INS will have three gyroscopes and three accelerometers.

Detailed Description Text (75):
As more sensors which are capable of providing information on the vehicle position, velocity and acceleration are added onto the vehicle, the system can become sufficiently complicated as to require a neural network, or neural-fuzzy, system to permit the optimum usage of the available information. This becomes even more important when information from outside the vehicle other than the GPS related systems becomes more available. For example, a vehicle may be able to communicate with other vehicles that have similar systems and learn their estimated location. If the vehicle can independently measure the position of the other vehicle, for example through the use of the scanning impulse laser radar system described below, and thereby determine the relative position of the two or more vehicles, a further improvement of the position can be determined for all such vehicles. Adding all such additional information into the system would probably require a computational method such as neural networks or a combination of a neural network and a fuzzy logic system.

Detailed Description Text (77):
One way to imagine the system operation is to consider each car and roadway edge to behave as if it had a surrounding "force field" that would prevent it from crashing into another vehicle or an obstacle along the roadway. A vehicle operator would be prevented from causing his or her vehicle to leave its assigned corridor. This is accomplished with a control system that controls the steering, acceleration and perhaps the vehicle brakes based on its knowledge of the location of the vehicle, highway boundaries and other nearby vehicles. In a preferred implementation, the location of the vehicle is determined by first using the GPS L1 signal to determine its location within approximately 100 meters. Then using DGPS and corrections which are broadcast whether by FM or downloaded from geo-synchronous or Low Earth Orbiting (LEO) satellites or obtained from road based transmitters to determine its location within less than about 10 centimeters. Finally the use of a MIR or similar system periodically permits the vehicle to determine its exact location and thereby determine the GPS corrections, eliminate the carrier cycle ambiguity and set the INS system. If this is still not sufficient, then the phase of the carrier frequency provides the required location information to less than a few centimeters. Dead reckoning, using vehicle speed, steering angle and tire rotation information and/or inertial guidance, can be used to fill in the gaps. Where satellites are out of view, pseudolites, or other systems, are placed along the highway. A pulsed scanning infrared laser radar system, or an equivalent system, is used for obstacle detection. Communication to other vehicles is by short distance radio or by spread spectrum time domain pulse radar as described by Time Domain Incorporated.

Detailed Description Text (78):
One problem which will require addressing as the system becomes mature is temporary blockage of a satellite by large trucks or other movable objects. whose location cannot be foreseen by the system designers. Another concern is to prevent vehicle owners from placing items on the vehicle exterior that block the GPS and communication antennas.

Detailed Description Text (80):
MIR might also be used for vehicle to vehicle communication except that it is line of sight. An advantage is that we can know when a particular vehicle will respond by range gating. Also, the short time of transmission permits many vehicles to communicate at the same time.

Detailed Description Text (83):
The use of an Ethernet protocol will satisfy the needs of the network, consisting of all threatening vehicles in the vicinity of the subject vehicle. Alternately, a network where the subject vehicle transmits a message to a particular vehicle and waits for a response could be used. From the response time, the relative position of other vehicles can be ascertained which provides one more method of position determination. Thus, the more vehicles that are on the road with the equipped system, the greater accuracy of the overall system and the safer the system becomes, as described above.

Detailed Description Text (84):
To prevent accidents caused by a vehicle leaving the road surface and impacting a roadside obstacle requires only an accurate knowledge of the position of the vehicle and the road boundaries. To prevent collisions with other vehicles requires that the position of all nearby automobiles must be updated continuously. But just knowing the position of a threatening vehicle is insufficient. The velocity, size and orientation of the vehicle are also important in determining what defensive action or reaction may be required. Once all vehicles are equipped with the system of this invention, the communication of all relevant information will take place via a communication link, e.g., a radio link. In addition to signaling its absolute position, each vehicle will send a message identifying the approximate mass, velocity, orientation, and other relevant information. This has the added benefit that emergency vehicles can make themselves known to all vehicles in their vicinity and all such vehicles can then take appropriate action. The same system can also be used to relay accident or other hazard information from vehicle to vehicle.

Detailed Description Text (87):
One preferred method of communication between vehicles uses that portion of the electromagnetic spectrum that permits only line of sight communication. In this manner, only those vehicles that are in view can communicate. In most cases. a collision can only occur between vehicles that can see each other. This system has the advantage that the "communications network" only contains nearby vehicles. This would require that when a truck. for example, blocks another stalled vehicle that the information from the stalled vehicle be transmitted via the truck to a following vehicle. An improvement in this system would use a rotating aperture that would only allow communication from a limited angle at a time further reducing the chance for multiple messages to interfere with each other. Each vehicle transmits at all angles but receives at only one angle at a time. This has the additional advantage of confirming at least the direction of the transmitting vehicle. An infrared rotating receiver can be looked at as similar to the human eye. That is, it is sensitive to radiation from a range of directions and then focuses in on the particular direction, one at a time, from which the radiation is coming. It does not have to scan continuously. In fact, the same transmitter which transmits 360 degrees could also receive from 360 degrees with the scanning accomplished using software.

Detailed Description Text (88):
An alternate preferred method is to use short distance radio communication so that a vehicle can receive position information from all nearby vehicles such as the DS/SS system. The location information received from each vehicle can then be used to eliminate it from further monitoring if it is found to be on a different roadway or not in a potential path of the subject vehicle.

Detailed Description Text (89):
Many communications schemes have been proposed for inter-vehicle and vehicle-to-road communication. At this, time, a suggested approach utilizes DS/SS communications in the 2.4 GHz INS band. Experiments have shown that communications are 100 percent accurate at distances up to 200 meters. At a closing velocity of 200 KPH, at 0.5 g deceleration, it requires 30 meters for a vehicle to stop. Thus, communication

accurate to 200 meters is sufficient to cover all vehicles that are threatening to a particular vehicle.

Detailed Description Text (94):
When two vehicles are communicating their positions to each other, it is possible through the use of range gating or the sending of a "clear to send signal" and timing the response to determine the separation of the vehicles. This assumes that the properties of the path between the vehicles is known which would be the case if the vehicles are within view of each other. If, on the other hand, there is a row of trees, for example, between the two vehicles, a false distance measurement would be obtained if the radio waves pass through a tree. If the communication frequency is low enough that it can pass through a tree in the above example, it will be delayed. If it is a much higher frequency such that is blocked by the tree then it still might reach the second vehicle through a multi-path. Thus, in both cases an undetectable range error results. If a range of frequencies is sent, as in a spread spectrum pulse, and the first arriving pulse contains all of the sent frequencies then it is likely that the two vehicles are in view of each other and the range calculation is accurate. If any of the frequencies are delayed then the range calculation can be considered inaccurate and should be ignored. Once again, for range purposes, the results of many transmissions and receptions can be used to improve the separation distance accuracy calculation. Alternate methods for determining range can make use of radar reflections, RFID tags etc.

Detailed Description Text (98):
In some cases, it may be necessary for one vehicle to communicate with another to determine which evasive action each should take. This could occur in a multiple vehicle situation when one car has gone out of control due to a blowout, for example. In such cases, one vehicle may have to tell the other vehicle what evasive actions it is planning. The other vehicle can then calculate whether it can avoid a collision based of the planned evasive action of the first vehicle and if not it can inform the first vehicle that it must change its evasive plans. The other vehicle would also inform the first vehicle as to what evasive action it is planning. Several vehicles communicating in this manner can determine the best paths for all vehicles to take to minimize the danger to all vehicles.

Detailed Description Text (102):
The initial maps showing roadway lane and boundary location for the CONUS should preferably be installed within the vehicle at the time of manufacture. The vehicle thereafter would check on a section by section basis whether it had the latest update information for the particular and surrounding locations where it is being operated. One method of verifying this information would be achieved if a satellite periodically broadcasts the latest date and time or version that each segment had been most recently updated. This matrix would amount to a small transmission requiring perhaps from a few seconds to one minute of airtime. Any additional emergency information could also be broadcast in between the periodic transmissions to cover accidents, trees falling onto roads etc. If the periodic transmission were to occur every five minutes and if the motion of a vehicle were somewhat restricted until it had received a periodic transmission, the safety of the system can be assured. If the vehicle finds that it does not have the latest map information, the cell phone in the vehicle can be used to log onto the Internet, for example, and the missing data downloaded. An alternate is for the LEOs, or other satellites, to broadcast the map corrections directly.

Detailed Description Text (103):
It is also possible that the map data could be off loaded from a transmitter on the highway itself. In that manner, the vehicles would only obtain that map information which it needed and the map information would always be up to the minute. As a minimum, temporal data communication stations can be placed before highway sections that are undergoing construction or where a recent blockage has occurred and where the maps have not yet been updated. Such an emergency data transfer would be signaled to all approaching vehicles to reduce speed and travel with care. Naturally such information could also contain maximum and minimum speed information which would limit the velocity of vehicles in the area.

Detailed Description Text (104):

There is other information that would be particularly useful to a vehicle operator or control system, including in particular the weather conditions especially at the road surface. Such information could be obtained by road sensors and then transmitted to all vehicles in the area by a permanently installed system. Alternately, there have been recent studies that show that icing conditions on road surfaces, for example, can be accurately predicted by local meteorological stations and broadcast to vehicles in the area. If such a system is not present, then, the best place to measure road friction is at the road surface and not on the vehicle. The vehicle requires advance information of an icing condition in order to have time to adjust its speed or take other evasive action. The same road based or local meteorological transmitter system could be used to warn the operators of traffic conditions, construction delays etc. and to set the local speed limit.

Detailed Description Text (106):
All information regarding the road, both temporary and permanent, should be part of the map database, including speed limits, presence of guard rails, width of each lane, width of the highway, width of the shoulder, character of the land beyond the roadway, existence of poles or trees and other roadside objects, exactly where the precise position location apparatus is located, etc. The speed limit associated with particular locations on the maps should be coded in such a way that the speeds limit can depend upon the time of day and the weather conditions. In other words, the speed limit is a variable that will change from time to time depending on conditions. It is contemplated that there will be a display for various map information present which will always be in view for the passenger and for the driver at least when the vehicle is operating under automatic control. Additional user information can thus also be displayed such as traffic conditions, weather conditions, advertisements, locations of restaurants and gas stations, etc.

Detailed Description Text (107):
A map showing the location of road and lane boundaries can be easily generated using a specially equipped survey vehicle that has the most accurate position measurement system available. In some cases, it might be necessary to set up one or more temporary local DGPS base stations in order to permit the survey vehicle to know its position within a few centimeters. The vehicle would drive down the roadway while operators, using specially designed equipment, sight the road edges and lanes. This would probably best be done with laser pointers and cameras. Transducers associated with the pointing apparatus record the angle of the apparatus and then by triangulation determine the distance of the road edge or lane marking from the survey vehicle. Since the vehicle's position would be accurately known, the boundaries and lane markings can be accurately determined. It is anticipated that the mapping activity would take place continuously such that all roads in a particular state would be periodically remapped in order to pickup up any changes which were missed by other monitoring systems and to improve the reliability of the maps by minimizing the chance for human error. Any roadway changes that were discovered would trigger an investigation as to why they were not recorded earlier thus adding feedback to the mapping part of the process.

Detailed Description Text (108):
The above-described method depends on human skill and attention and thus is likely to result in many errors. A preferred approach is to carefully photograph the edge of the road and use the laser pointers to determine the location of the road lines relative to the pointers and to determine the slope of the roadway through triangulation. In this case several laser pointers would be used emanating from above, below and to the sides of the camera. The reduction of the data is then done later using equipment that can automatically pick out the lane markings and the reflected spots from the laser pointers. One aid to the mapping process is to place chemicals in the line paint that could be identified by the computer software when the camera output is digitized. This may require the illumination of the area being photographed by an infrared or ultraviolet light, for example.

Detailed Description Text (109):
In some cases where the roadway is straight, the survey vehicle could travel at moderate speed while obtaining the boundary and lane location information. In other cases, where the road in turning rapidly, more readings would be required per mile and the survey vehicle would need to travel more slowly. In any case, the required road information can be acquired semi-automatically with the survey vehicle traveling at a

moderate speed. Thus, the mapping of a particular road would not require significant time or resources. It is contemplated that a few such survey vehicles could map all of the interstate highways in the United States in less than one year.

Detailed Description Text (110):
The mapping effort could be supplemented and cross-checked though the use of accurate detailed digital photogrammetic systems which, for example, can determine the road altitude with an accuracy to <50 cm. Efforts are underway to map the earth with 1-meter accuracy. The generated maps could be used to check the accuracy of the road-determined maps.

Detailed Description Text (111):
Another improvement that can be added to the system based on the maps is to use a heads up display for in-vehicle signage. As the vehicle travels down the road, the contents of road side signs can be displayed on a heads up display, providing such a display is available in the vehicle, or on a specially installed LCD display. This is based on the inclusion in the map database the contents of all highway signs. A further improvement would be to include signs having varying messages which would require that the message be transmitted by the sign to the vehicle and received and processed for in vehicle display.

Detailed Description Text (112):
As the roadway is being mapped, the availability of GPS satellite view, and the presence of multipath reflections from fixed structures can also be determined. This information can then be used to determine the advisability of locating a local precise location system, or other infrastructure at a particular spot on the roadway. Cars can also be used as probes for this process and for continuous improvement to check the validity of the maps and report any errors.

Detailed Description Text (116):
On the other hand, it has been estimated that there are 100,000 vehicles on the road, many of them stolen, where the operators do not want the vehicle to be identified. If an identification process that positively identifies the vehicle were made part of this system, it could thus cut down on vehicle theft. Alternately, thieves might attempt to disconnect the system thereby defeating the full implementation of the system and thus increasing the danger on the roadways and defeating the RTZF objective. The state of the system would therefore need to be self-diagnosed and system readiness must be a condition for entry onto the restricted lanes.

Detailed Description Text (119):
Vehicles with the RtZF.TM. system in accordance with the invention must also be able to detect those vehicles that do not have the system as well as pedestrians, animals, bicyclists, and other hazards that may cross the path of the equipped vehicle.

Detailed Description Text (121):
Although, there appears not to be any significant prior art involving a vehicle communicating safety information to another vehicle on the roadway, several patents discuss methods of determining that a collision might take place using infrared and radar. U.S. Pat. No. 5,249,128 to Markandey et al., for example, discusses methods of using infrared to determine the distance to a vehicle in front and U.S. Pat. No. 5,506,584 to Boles describes a radar-based system. Both systems suffer from a high false alarm rate and could be substantially improved if a pattern recognition system such as neural networks were used.

Detailed Description Text (126):
This brings up a philosophical discussion about the trade-offs between radar with greater range and infrared laser radar with more limited range but greater resolution. At what point should driving during bad weather conditions be prohibited? If the goal of zero fatalities is to be realized, then people should not be permitted to operate their vehicles during dangerous weather conditions. This may require closing roads and highways prior to the start of such conditions. Under such a policy, a system which accurately returns images of obstacles on the roadway that are two to five times the visual distance should be adequate. In such a case, radar would not be necessary.

Detailed Description Text (128):

The digital map can be used to define the field that the laser radar scanner will interrogate. The laser radar scanner will return information as to distance to an object in the scanned field. This will cover all objects that are on or adjacent to the highway. The laser pulse can be a pixel that is one inch in diameter at 100 feet, for example. The scanner must scan the entire road at such a speed that the motion of the car can be considered insignificant. Alternately, a separate aiming system that operates at a much lower speed, but at a speed to permit compensation for the car angle changes. Such an aiming system is also necessary due to the fact that the road curves up and down. Therefore two scanning methods, one a slow, but for large angle motion and the other fast but for small angles may be required. The large angular system requires a motor drive while the small angular system can be accomplished through the use of an acoustic wave system, such as Lithium Niobate (LiNbO.sub.3), which is used to drive a crystal which has a large refractive index such as Tellurium dioxide.

Detailed Description Text (131):
Prior to the time that all vehicles are equipped with the RtZF system described above, roadways will consist of a mix of vehicles. In this period, it will not be possible to totally eliminate accidents. It will be possible to minimize the probability of having an accident however, if a laser radar system similar to that described in Shaw (U.S. Pat. No. 5,529,138) with some significant modifications is used. It is correctly perceived by Shaw that the dimensions of a radar beam are too large to permit distinguishing various objects which may be on the roadway in the path of the instant vehicle. Laser radar provides the necessary resolution that is not provided by radar. Laser radar as used in the present invention however would acquire significantly more data than anticipated by Shaw. Sufficient data in fact would be attained to permit the acquisition of a 3-dimensional image of all objects in the field of view. The X and Y dimensions of such objects would, of course, be determined knowing the angular orientation of the laser radar beam. The longitudinal or Z dimension would be obtained by the time-of-flight of the laser beam to a particular point on the object and reflected back to the detector or by phase methods.

Detailed Description Text (137):
Although the system described above is intended for collision avoidance or at least the notification of a potential collision, when the roadway is populated by vehicles having the RtZF.TM. system and vehicles which do not, its use is still desirable after all vehicles are properly equipped. It can also be used to search for animals or other objects which may be on or crossing the highway, a box dropping off of a truck for example, a person crossing the road who is not paying attention to traffic. Naturally motorcycles, bicycles, and other vehicles can also be monitored.

Detailed Description Text (138):
One significant problem with all previous collision avoidance systems which use radar or laser radar systems to predict impacts with vehicles, is the inability to known whether the vehicle that is being interrogated is located on the highway or is off the road. In the system of the present invention, the location of the road at any distance ahead of the vehicle would be known precisely from the sub-meter accuracy maps, so that the scanning system can ignore, for example, all vehicles on lanes where there is a physical barrier separating the lanes from the lane on which the subject vehicle is traveling. This, of course, is a common situation on super highways. Similarly, a parked car on the side of the car would not be confused with a parked car that is in the lane of travel of the subject vehicle when the road is curving. This permits the subject invention to be used for automatic cruise control. In contrast with radar systems, it does not require that vehicles in the path of the subject vehicle to be moving, so that high speed impacts into stalled traffic can be avoided.

Detailed Description Text (139):
If a system with a broader beam to illuminate a larger area on the road in front of the subject vehicle is used, with the subsequent focusing of this image onto a CCD or CMOS array, this has an advantage of permitting a comparison of the passive infrared signal and the reflection of the laser radar active infrared. Metal objects, for example appear cold to passive infrared. This permits another parameter to be used to differentiate metallic objects from non-metallic objects such as foliage or animals such as deer. The breadth of the beam can be controlled and thereby a particular object can be accurately illuminated. With this system, the speed with which the beam

steering is accomplished can be much slower. Naturally, both systems can be combined into the maximum amount of information to be available to the system.

Detailed Description Text (145):
The RtZF.TM. system in accordance with the invention eliminates the shortcomings of the prior art by providing a system that does not require modifications to the highway. The information as to the location of the highway is determined, as discussed above, by mapping the edges of the roadway and the edges of the lanes of the roadway using a process whereby the major roads of the entire country can be mapped at very low cost. Thus, the system has the capability of reducing congestion as well as saving lives on all major roads, not just those which have been selected as high-speed guided lanes.

Detailed Description Text (148):
The RtZF.TM. system in accordance with the present invention satisfies all of these goals at a small fraction of the cost of prior art systems. The safety benefits have been discussed above. The capacity increase is achieved by confining vehicles to corridors where they are then permitted to travel at higher speeds. This can be achieved immediately where carrier phase DGPS is available or with the implementation of the highway located precise location systems as shown in FIG. 11. An improvement is to add the capability for the speed of the vehicles to be set by the highway. This is a simple additional few bytes of information that can be transmitted along with the road edge location map, thus, at very little initial cost. To account for the tolerances in vehicle speed control systems, the scanning laser radar, or other technology system, which monitors for the presence of vehicles without RtZF.TM. is also usable as an adaptive cruise control system. Thus, if a faster moving vehicle approaches a slower moving vehicle, it will automatically slow down to keep a safe separation distance from the leading, slower moving vehicle. Although the system is not planned for platooning, that will be the automatic result in some cases. The maximum packing of vehicles is automatically obtained and thus the maximum vehicle flow rate is also achieved with a very simple system.

Detailed Description Text (149):
For the Intelligent Highway System (ITS) application, some provision is required to prevent unequipped vehicles from entering the restricted lanes. In most cases, a barrier will be required since if an errant vehicle did enter the controlled lane, a serious accident could result. Vehicles would be checked while traveling down the road or at a tollbooth, or similar station, that the RtZF.TM. system was in operation without faults and with the latest updated map for the region. Only those vehicles with the RtZF.TM. system in good working order would be permitted to enter. The speed on the restricted lanes would be set according to the weather conditions and fed to the vehicle information system automatically, as discussed above.

Detailed Description Text (150):
For ITS use, there needs to be a provision whereby a driver can signal an emergency, for example, by putting on the hazard lights. This would permit the vehicle to leave the roadway and enter the shoulder when the vehicle velocity is below some level. Once the driver provides such a signal, the roadway information system, or the network of vehicle based control systems, would then reduce the speed of all vehicles in the vicinity until the emergency has passed. This roadway information system need not be actually associated with the particular roadway and also need not require any roadway infrastructure. It is a term used here to represent the collective system as operated by the network of nearby vehicles and the inter-vehicle communication system. Eventually, the occurrence of such emergency situations will be eliminated by vehicle based failure prediction systems such as described in U.S. Pat. No. 5,809,437 which is incorporated by reference herein in its entirety.

Detailed Description Text (153):
The spacing of the vehicles is the first line of defense. Secondly, each vehicle with a RtZF.TM. system has the ability to automatically communicate to all adjacent vehicles and thus immediately issue a warning when an emergency event is occurring. Finally, with the addition of a total vehicle diagnostic system, such as disclosed in U.S. Pat. No. 5,809,437 (Breed), "On Board Vehicle Diagnostic System", potential emergencies can be anticipated and thus eliminated with high reliability.

Detailed Description Text (154):
Although the application for ITS envisions a special highway lane and high speed travel, the potential exists in the invention to provide a lower measure of automatic guidance where the operator can turn control of the vehicle over to the RtZFrM system for as long as the infrastructure is available. In this case, the vehicle would operate in normal lanes but would retain its position in the lane and avoid collisions until a decision requiring operator assistance is required. At that time, the operator would be notified and if he or she did not assume control of the vehicle, an orderly stopping of the vehicle on the side of the road would occur.

Detailed Description Text (165):
The system also solves the automatic headlight dimmer problem. Since the RtZF.TM. system equipped vehicle knows where all other RtZF.TM. system equipped vehicles are located in its vicinity, it knows when to dim the headlights. Since it is also interrogating the environment in front of the vehicle, it also knows the existence and approximate location of all non-RtZF.TM. system equipped vehicles. This is one example of a future improvement to the system. The RtZF.TM. system is a system which lends itself to continuous improvement without having to change systems on an existing vehicle.

Detailed Description Text (168):
For large trucks that have varying inertial properties depending on the load that is being hauled, sensors can be placed on the vehicle that measure the angular and linear acceleration of a part of the vehicle. Since the geometry of the road is known, the inertial properties of the vehicle with load can be determined and thus the tendency of the vehicle to roll over can be determined. Again, since the road geometry is known the speed of the truck can be limited to prevent rollovers.

Detailed Description Text (173):
GPS and Other Measurement Improvements

Detailed Description Text (174):
One of the possible problems with the RtZF.TM. system described herein is operation in large cities such as downtown New York. In such locations. unless there are a plurality of local pseudolites or precise position location system installations, the signals from the GPS satellites can be significantly blocked. Also there is a severe multipath problem. A solution is to use the LORAN system as a backup for such locations. The accuracy of LORAN can be comparable to DGPS. Naturally, the use of multiple roadway located precise positioning systems would be a better solution or a complementary solution. Additionally, some location improvement can result from application of the SnapTrack system as described in U.S. Pat. No. 5,874,914 which is included herein by reference and other patents to Krasner of SnapTrack.

Detailed Description Text (176):
Another enhancement that would be possible with dedicated satellites and/or earth bound pseudolites results from the greater control over the information transmitted than is available from the GPS system. Recognizing that this system could save up to 40,000 lives per year in the U.S. alone, the cost of deploying such special purpose stations can easily be justified. For example, say there exists a modulated wave that is 10000 kilometers long, another one which is 1000 km long etc. down to 1 cm. It would then be easy to determine the absolute distance from one point to the other. Other types of modulation are of course possible to achieve the desired result of simply eliminating the carrier integer uncertainty that is discussed in many U.S. patents and other literature. This is not meant to be a recommendation but to illustrate that once the decision has been made to provide information to every vehicle that will permit it to always know its location within 10 cm, many technologies will be there to make it happen. The cost savings resulting from eliminating fatalities and serious injuries will easily cover the cost of such technologies many times over.

Detailed Description Text (181):
Since the road conditions will now be known to the system, an enhanced RtZF.TM. system will be able to advise an operator not to travel or, alternately, it can pick an alternate route if certain roads have accidents or have iced over, for example. Some people may decide not drive if there is bad weather or congestion. The important point

here is that sensors will be available to sense the road condition as to both traffic and weather, this information will be available automatically and not require reporting from weather stations which usually have only late and inaccurate information. Additionally, pricing for the use of certain roads can be based on weather, congestion, time of day, etc. That is, pricing can by dynamically controlled.

Detailed Description Text (185):
Once the road edge and lane locations, and other roadway information, are transmitted to the operator, it requires very little additional bandwidth to include other information such as the location of all businesses that a traveler would be interested in such as gas stations, restaurants etc. which could be done on a subscription basis. This concept was partially disclosed in the '482 patent discussed above and partially implemented in existing map databases.

Detailed Description Text (186):
Naturally, the communication of information to the operator could be done either visually or orally as described in U.S. Pat. No. 5,177,685 or U.S. provisional patent application Serial No. 60/170,973 filed Dec. 15, 1999, both of which are incorporated by reference herein. Finally, the addition of a route guidance system as described in other patents becomes even more feasible since the exact location of a destination can be determined. The system can be configured so that a vehicle operator could enter a phone number, for example, or an address and the vehicle would be automatically and safely driven to that location. Since the system knows the location of the edge of every roadway, very little, if any, operator intervention would be required. Even a cell phone number can be used if the cell phone has the SnapTrack GPS location system as soon to be provided by Qualcomm.

Detailed Description Text (188):
The RtZF.TM. system can even replace other sensors now on or being considered for automobile vehicles including pitch, roll and yaw sensors. This information can be found by using carrier phase GPS and by adding more antennas to the vehicle. Additionally, once the system is in place for land vehicles, there will be many other applications such as surveying, vehicle tracking and aircraft landing which will benefit from the technology and infrastructure improvements. The automobile safety issue and ITS will result in the implementation of a national system which provides any user with low cost equipment the ability to know precisely where he is within centimeters on the face of the earth. Many other applications will undoubtedly follow.

Detailed Description Text (194):
The second technical problem is the integrity of the signals being received and the major cause of the lack of integrity is the multi-path effect. Considerable research has gone into solving the multi-path effect and Trimble claims that this problem is no longer an issue.

Detailed Description Text (195):
The third area is availability of GPS and DGPS signals to the vehicle as it is driving down the road. The system is designed to tolerate temporary losses of signal, up to a few minutes. That is the prime function of the inertial navigation system (INS). Prolonged absence of the GPS signal will significantly degrade system performance. There are two primary causes of lack of availability, namely, temporary causes and permanent causes. Temporary causes result from a car driving between two trucks for an extended period of time, blocking the GPS signals. The eventual solution to this problem is to change the laws to prevent trucks from traveling on both sides of an automobile. If this remains a problem, a warning will be provided to the driver that he/she is losing system integrity and therefore he/she should speed up or slow down to regain a satellite view. This could also be done automatically.

Detailed Description Text (196):
Permanent blockage of the GPS signals, as can come from operating the vehicle in a tunnel or in the downtown of a large city, can be corrected through the use of pseudolites or other guidance systems such as the SnapTrack system or the PPS described here. This is not a serious problem since very few cars run off the road in a tunnel or in downtown Manhattan.

Detailed Description Text (200):
A similar argument can be made for the inertial navigation system. Considerable research and development effort is ongoing to reduce the size, complexity and cost of these systems. Three technologies are vying for this rapidly growing market: laser gyroscopes, fiber-optic lasers, and MEMS systems. The cost of these units today range from a few hundred and ten thousand dollars each, however, once again this is due to the very small quantity being sold. Substantial improvements are being made in the accuracies of the MEMS systems and it now appears that such a system will be accurate enough for RtZF.TM. purposes. The cost of these systems in high-volume production is expected to be below ten dollars each. This includes at least a yaw rate sensor with three accelerometers and probably three angular rate sensors. The accuracy of these units is currently approximately 0.003 degrees per second. This is a random error which can be corrected somewhat by the use of multiple vibrating elements. A new laser gyroscope has recently been announced by Intellisense Corporation which should provide a dramatic cost reduction and accuracy improvement.

Detailed Description Text (201):
Eventually when most vehicles on the road have the RtZF.TM. system then communication between the vehicles can be used to substantially improve the location accuracy, of each vehicle as described above.

Detailed Description Text (202):
The cost of mapping the continental United States (CONUS) is largely an unknown at this time. OmniSTAR has stated that they will map any area with sufficient detail at a cost of $300 per mile. They have also indicated the cost will drop substantially as the number of miles to be mapped increases. This mapping would be done by helicopter using cameras and their laser ranging system. Another method is to outfit a ground vehicle with equipment that will determine the location of the lane and shoulder boundaries of road and other information. Such a system has been used for mapping a Swedish highway. One estimate is that the mapping of a road will be reduced to approximately $50 per mile for major highways and rural roads and a somewhat higher number for urban areas. The,goal is to map the country to an accuracy of 2 centimeters (1.sigma.).

Detailed Description Text (203):
Related to the costs of mapping is the cost of converting the raw data acquired either by helicopter or by ground vehicle into a usable map database. The cost for manually performing this vectorization process has been estimated at $100 per mile by OmniSTAR. This process can be substantially simplified through the use of raster to vector conversion software. Such software is currently being used for converting hand drawings into CAD systems, for example. The Intergraph Corp. provides hardware and software for simplifying this task. It is therefore expected that the cost for vectorization of the map data will follow proportionately a similar path to the cost of acquiring the data and may eventually reach $10 to $20 per mile for the rural mapping and $25 to a $50 per mile for urban areas. Considering that there are approximately four million miles of roads in the CONUS, and assuming we can achieve an average of $150 for acquiring the data and converting the data to a GIS database can be achieved, the total cost for mapping all of the roads in United States will amount to $600 million. This cost would obviously be spread over a number of years and thus the cost per year is manageable and small in comparison to the $215 billion lost every year due to death, injury and lost time from traffic congestion.

Detailed Description Text (205):
The next impediment is the lack of a system for determining when changes are planned for the mapped roads. This will require communication with all highway and road maintenance organizations in the mapped area.

Detailed Description Text (210):
Assumptions for the Application Benefits Analysis The high volume incremental cost of an automobile will be $200. The cost of DGPS correction signals will be a onetime charge of $50 per vehicle. The benefits to the vehicle owner from up-to-date maps and to the purveyors of services located on these maps. will cover the cost of updating the maps as the roads change. The cost of mapping substantially all roads in the Continental U.S. will be $600 million. The effects of phasing in the system will be

ignored. There are 15 million vehicles sold in the U.S. each year. Of the 40,000 plus people killed on the roadways, at least 10% are due to road departure, yellow line infraction, stop sign infraction, excessive speed and other causes which will be eliminated by the Phase Zero deployment. $165 billion are lost each year due to highway accidents. The cost savings due to secondary benefits will be ignored.

Detailed Description Text (212):
The analysis method will be quite simple. Assume that 10% of the vehicles on the road will be equipped with RtZF.TM. systems in the first year and that this will increase by 10 percent each year. Ten percent or 4000 lives will be saved and a comparable percentage of injuries. Thus, in the first year, one percent of $165 billion dollars will be saved or $1.65 billion. In the second year, this saving will be $3.3 billion and the third year $4.95 billion. The first-year cost of implementation of the system will be $600 million for mapping and $3.75 billion for installation onto vehicles. The first year cost therefore will be $4.35 billion and the cost for the second and continuing years will be $3.75 billion. Thus, by the third year the benefits exceed the costs and by the 10th year the benefits will reach $16.5 billion compared with costs of $3.75 billion yielding a benefits to cost ratio of more than 4.

Detailed Description Text (214):
It is also believed that the percentage reduction of fatalities and injuries has been substantially understated. For the first time, there will be some control over the drunk or otherwise incapacitated driver. If the excessive speed feature is implemented, then gradually the cost of enforcing the nation's speed limits will begin to be substantially reduced. Since it is expected that large trucks will be among first vehicles to be totally covered with the system, perhaps on a retrofit basis, it is expected that the benefits to commercial vehicle owners and operators will be substantial. Naturally, the retrofit market may rapidly develop and the assumptions of vehicles with deployed systems may be low. None of these effects have been taken into account in the above analysis.

Detailed Description Text (217):
The initial implementation of the RtZF.TM. system would include the following services: 1. A warning is issued to the driver when the driver is about to depart from the road. 2. A warning is issued to the driver when the driver is about to cross a yellow line or other lane boundary. 3. A warning is provided to the driver when the driver is exceeding a safe speed limit for the road geometry. 4. A warning is provided to the driver when the driver is about to go through a stop sign without stopping. 5. A warning is provided to the driver when the driver is about run the risk of a rollover. 6. A warning will be issued prior to a rear end impact by the equipped vehicle. 7. In-vehicle signage will be provided for highway signs. 8. A recording will be logged whenever a warning is issued.

Detailed Description Text (219):
FIG. 1 shows the current GPS satellite system associated with the earth and including 24 satellites 2, each satellite revolving in a specific orbital path 4 around the earth. By means of such a GPS satellite system, the position of any object can be determined with varying degrees of precision as discussed in detail above.

Detailed Description Text (220):
FIG. 2 shows an arrangement of four satellites 2 designated SV.sub.1, SV.sub.2, SV.sub.3 and SV.sub.4 of the GPS satellite system shown in FIG. 1 transmitting position information to receiver means of a base station 20, such as an antenna 22, which in turn transmits a differential correction signal via transmitter means associated with that base station, such as a second antenna 16, to a vehicle 18.

Detailed Description Text (222):
FIG. 3 shows an arrangement of four satellites 2 designated SV.sub.1, SV.sub.2, SV.sub.3 and SV.sub.4 of the GPS satellite system as in FIG. 2 transmitting position information to receiver means of base stations 20 and 21, such as an antenna 22, which in turn transmit a differential correction signal via transmitter means associated with that base stations, such as a second antenna 16, to a geocentric or low earth orbiting (LEO) satellite 30 which in turn transmits the differential correction signals to vehicle 18. In this case, one or more of the base stations 20,21 receives and performs a mathematical analysis on all of the signals received from a number of

base stations that cover the area under consideration and forms a mathematical model of the errors in the GPS signals over the entire area. For the continental United States, for example, a group of 13 base stations are operated by OmniStar that are distributed around the country. By considering data from the entire group of such stations, the errors in the GPS signals for the entire area can be estimated resulting in a position accuracy of about 6-10 cm over the entire area. The corrections are then uploaded to the geocentric or low earth orbiting satellite 30 for retransmission to vehicles on the roadways. In this way, such vehicles are able to determine their absolute position to within about 6-10 centimeters. This is known as Wide Area Deferential GPS or WADGPS.

Detailed Description Text (224):
FIG. 4 is a logic diagram of the system 50 in accordance with the invention showing the combination 40 of the GPS and DGPS processing systems 42 and an inertial reference unit (IRU) or inertial navigation system 44. The GPS system includes a unit for processing the received information from the satellites 2 of the GPS satellite system, the information from the satellites 30 of the DGPS system and data from the inertial reference unit (IRU) 44. The inertial reference unit 44 contains accelerometers and laser or MEMS gyroscopes.

Detailed Description Text (225):
The system shown in FIG. 4 is a minimal RtZF.TM. system that can be used to prevent road departure, lane crossing and intersection accidents, which together account for more than about 50% of the fatal accidents in the United States.

Detailed Description Text (226):
Map database 48 works in conjunction with a navigation system 46 to provide a warning to the driver when he or she is about to run off the road, cross a yellow line, run a stop sign, or run a red stoplight. The map database 48 contains a map of the roadway to an accuracy of 2 cm (1 sigma), i.e., data on the edges of the lanes of the roadway and the edges of the roadway, and the location of all stop signs and stoplights and other traffic control devices such as other types of road signs. Another sensor, not shown, provides input to the vehicle indicating that an approaching stoplight is red, yellow or green. Navigation system 46 is coupled to the GPS and DGPS processing system 42. For this simple system, the driver is warned if any of the above events is detected by a driver warning system 45 coupled to the navigation system 46. The driver warning system 45 can be an alarm, light, buzzer or other audible noise, or, preferably, a simulated rumble strip for yellow line and "running off of road" situations and a combined light and alarm for the stop sign and stoplight infractions.

Detailed Description Text (228):
As illustrated in FIG. 5, the vehicle accident avoidance system is implemented using a variety of microprocessors and electronic circuits 100 to interconnect and route various signals between and among the illustrated subsystems. GPS receiver 52 is used to receive GPS radio signals as illustrated in FIG. 1. DGPS receiver 54 receives the differential correction signals from one or more base stations either directly or via a geocentric stationary or LEO satellite. Inter-vehicle communication subsystem 56 is used to transmit and receive information between various nearby vehicles. This communication will in general take place via broad band or ultra-broad band communication techniques, or on dedicated frequency radio channels. This communication may be implemented using multiple access communication methods including frequency division multiple access (FDMA), timed division multiple access (TDMA), or code division multiple access (CDMA) in a manner to permit simultaneous communication with and between a multiplicity of vehicles. Naturally, other forms of communication between vehicles are possible such as through the Internet. This communication will consist of such information as the precise location of a vehicle, the latest received signals from the GPS satellites in view, other road condition information, emergency signals, hazard warnings, vehicle velocity and intended path, and any other information which is useful to improve the safety of the vehicle road system.

Detailed Description Text (229):
Infrastructure communication system 58 permits bidirectional communication between the host vehicle and the infrastructure and includes such information transfer as updates to the digital maps, weather information, road condition information, hazard

information, congestion information, temporary signs and warnings, and any other information which can improve the safety of the vehicle highway system.

Detailed Description Text (230):
Cameras 60 are used generally for interrogating environment nearby the host vehicle for such functions as blind spot monitoring, backup warnings, anticipatory crash sensing, visibility determination, lane following, and any other visual information which is desirable for improving the safety of the vehicle highway system. Generally, the cameras will be sensitive to infrared and/or visible light, however, in some cases a passive infrared camera will the used to detect the presence of animate bodies such as deer or people on the roadway in front of the vehicle. Frequently, infrared or visible illumination will be provided by the host vehicle.

Detailed Description Text (231):
Radar 62 is primarily used to scan an environment further from the vehicle than the range of the cameras and to provide an initial warning of potential obstacles in the path of the vehicle. The radar 62 can also be used when conditions of a reduced visibility are present to provide advance warning to the vehicle of obstacles hidden by rain, fog, snow etc. Pulsed, continuous wave or micropower impulse radar systems can be used as appropriate. Also Doppler radar can be used to determine the object to host vehicle relative velocity.

Detailed Description Text (232):
Laser radar 64 is primarily used to illuminate potential hazardous objects that are in the path of the vehicle. Since the vehicle will be operating on accurate mapped roads, the precise location of objects discovered by he radar or camera systems can be determined using range gating and scanning laser radar as described above or phase techniques.

Detailed Description Text (233):
The driver warning system 66 provides visual and audible warning messages to the driver or others that a hazard exists. In addition to activating a warning system within the vehicle, this system can activate sound and light systems to warn other people, animals, or vehicles of a pending hazardous condition. In such cases, the warning system could activate the vehicle headlights, tail lights, horn and/or the vehicle to vehicle, internet or infrastructure communication system to inform other vehicles, a traffic control station or other base station. This system will be important during the early stages of implementation of RtZF, however as more and more vehicles are equipped with the system, there will be less to warn the driver or others of potential problems.

Detailed Description Text (234):
Map database subsystem 68, which could reside on an external memory module, will contain all of the map information such as road edges to 2 cm accuracy, the locations of stop signs, stoplights, lane markers etc. as described in detail above. The fundamental map data can be organized on read-only magnetic or optical memory with a read/write associated memory for storing map update information. Alternatively, the map information can be stored on rewritable media that can be updated with information from the infrastructure communication subsystem 58. This updating can take place while the vehicle is being operated or, alternatively, while the vehicle is parked in a garage or on the street.

Detailed Description Text (236):
As a check on the inertial system, a velocity sensor 76 based on a wheel speed sensor, for example, can be provided for the system. Other systems are preferably used for this purpose such as the GPS/DGPS or precise position systems.

Detailed Description Text (237):
The inertial navigation unit, sometimes called the inertial reference unit or IRU, comprises one or more accelerometers 78 and one or more gyroscopes 80. Usually, three accelerometers would be required to provide the vehicle acceleration in the latitude, longitude and vertical directions and three gyroscopes would be required to provide the angular rate about the pitch, yaw and roll axes.

Detailed Description Text (238):

Display subsystem 82 includes an appropriate display driver and either a heads-up or other display system for providing system information to the vehicle operator. The information can be in the form of non-critical information such as the location of the vehicle on a map, as chosen by the vehicle operator and/or it can consist of warning or other emergency messages provided by the vehicle subsystems or from communication with other vehicles or the infrastructure. An emergency message that the road has been washed out ahead, for example, would be an example of such a message.

Detailed Description Text (242):
In some locations where weather conditions can deteriorate and degrade road surface conditions, various infrastructure-based sensors can be placed either in or adjacent to the road surface. Subsystem 88 is designed to interrogate and obtained information from such road-based systems. An example of such a system would be an RFID tag containing a temperature sensor. This device may be battery-powered or, preferably, would receive its power from the vehicle-mounted interrogator, or other host vehicle-mounted source, as the vehicle passes nearby the device. In this manner, the vehicle can obtain the temperature of the road surface and receive advanced warning when the temperature is approaching conditions which could cause icing of the roadway, for example. An infrared sensor on the vehicle can also be used to determine the road temperature and the existence of ice or snow.

Detailed Description Text (245):
Although atomic clocks are probably too expensive to the deployed on automobiles, nevertheless there has been significant advances recently in the accuracy of clocks to the extent that it is now feasible to place a reasonably accurate clock as a subsystem 94 to this system. Since the clock can be recalibrated from each GPS transmission, the clock drift can be accurately measured and used to predict the precise time even though the clock by itself may be incapable of doing so. To the extent that the vehicle contains an accurate time source, the satellites in view requirement can temporarily drop from 4 to 3.

Detailed Description Text (247):
The control processor or central processor and circuit board subsystem 100 to which all of the above components 52-98 are coupled, performs such functions as GPS ranging, DGPS corrections, image analysis, radar analysis, laser radar scanning control and analysis of received information, warning message generation, map communication, vehicle control, inertial navigation system calibrations and control, display control, precise positioning calculations, road condition predictions, and all other functions needed for the system to operate according to design.

Detailed Description Text (262):
FIG. 7 shows the implementation of the invention in which a vehicle 18 is traveling on a roadway in a defined corridor in the direction X. Each corridor is defined by lines 14. If the vehicle is traveling in one corridor and strays in the direction Y so that it moves along the line 22, e.g., the driver is falling asleep, the system on board the vehicle in accordance with the invention will activate a warning. More specifically, the system continually detects the position of the vehicle, such as by means of the GPS, DGPS and PPS, and has stored the locations of the lines 14 defining the corridor. Upon an intersection of the position of the vehicle and one of the lines 14 as determined by a processor, the system may be designed to sound an alarm to alert the driver to the deviation or possibly even correct the steering of the vehicle to return the vehicle to within the corridor defined by lines 14.

Detailed Description Text (263):
FIG. 8 shows the implementation of the invention in which a pair of vehicles 18, 26 are traveling on a roadway each in a defined corridor defined by lines 14 and each is equipped with a system in accordance with the invention. The system in each vehicle 18,26 will receive data informing it of the position of the other vehicle and prevent accidents from occurring, e.g., if vehicle 18 moves in the direction of arrow 20. This can be accomplished via direct wireless broad band communication, or through another path such as via the Internet or through a base station. wherein each vehicle transmits its best estimate of its absolute location on the earth along with an estimate of the accuracy of this location. If one of the vehicles has recently passed a precise positioning station, for example, then it will know its position stern accurately to within 2 centimeters, for example. Each vehicle will also send the

latest satellite messages that it received permitting each vehicle to precisely determine its relative location to the other since the errors in the signals will be the same for both vehicles. To the extent that both vehicles are near each other, even the carrier phase ambiguity can be determined and each vehicle will know its position relative to the other to within better than 2 centimeters. As more and more vehicles become part of the community and communicate their information to each other, each vehicle can even more accurately determine its absolute position and especially if one vehicle knows its position very accurately, if it recently passed a PPS for example, then all vehicles will know their position with approximately the same accuracy and that accuracy will be able to be maintained for as long as a vehicle keeps its lock on the satellites in view. If that lock is lost temporarily, the INS system will fill in the gaps and, depending on the accuracy of that system, the approximate 2 centimeter accuracy can be maintained even if the satellite lock is lost for up to approximately five minutes.

Detailed Description Text (281):
Although the MIR systems are relatively inexpensive, on the order of ten dollars each, the installation cost of the system will be significantly higher than the RFID solution discussed next. The MIR system is also significantly more complex than the RFFD system; however, its accuracy can be checked by each vehicle that uses the system. Tying the MIR system to a GPS receiver and using the accurate clock on the GPS satellites as the trigger for the sending of the radar pulses can add additional advantages and complexity. This will permit vehicles passing by to additionally accurately set their clocks to be in synchronization with the GPS clocks. Since the MIR system will know its precise location, all errors in the GPS signals can be automatically corrected and in that case, the MIR system becomes a differential GPS base station. For most implementations, this added complexity is not necessary since the vehicle themselves will be receiving GPS signals and they will also know precisely their location from the MIR transmitter triad 151,152,153.

Detailed Description Text (284):
Using the PPS system, a vehicle can precisely determine its location within two centimeters or better relative to the MIR or RFID tags and since the precise location of these devices has previously been recorded on the map database, the vehicle will be able to determine its precise location on the surface of the earth. With this information, the vehicle will be thereafter able to use the carrier wave phase to maintain its precise knowledge of its location until the locks on the satellites arc lost. Similarly, the vehicle 18 can broadcast this information to vehicle 26, for example, permitting a vehicle that has not passed through the PPS triad to also greatly improve the accuracy with which it knows its position. Each vehicle that has recently passed through a PPS triad now becomes a differential GPS station for as long as the satellite locks are maintained. Therefore, through inter-vehicle communications, all vehicles in the vicinity can also significantly improve their knowledge of their position accuracy resulting in a system which is extremely redundant and therefore highly reliable and consistent with the "Road to Zero Fatalities".TM. process. Once this system is operational, it is expected that the U.S. and other governments will launch additional GPS type satellites, or other similar satellites, further strengthening the system and adding further redundancy eventually resulting in a highly interconnected system that approaches 100% reliability and, like the Internet, cannot be shut down.

Detailed Description Text (288):
From the above discussion, those skilled in the art will think of other devices that can be interrogated by a vehicle traveling down the road. Such devices might include radar reflectors, mirrors, other forms of transponders, or other forms of energy reflectors. All such devices are contemplated by this invention and the invention is not limited to be specific examples described.

Detailed Description Text (291):
FIG. 12a is a flow chart of the method in accordance with the invention. The absolute position of the vehicle is determined at 130, e.g., using a GPS, DGPS PPS system, and compared to the edges of the roadway at 134, which is obtained from a memory unit 132. Based on the comparison at 134, it is determined whether the absolute position of the vehicle is approaching close to or intersects an edge of the roadway at 136. If not, then the position of the vehicle is again obtained, e.g., at a set time interval

thereafter, and the process continues. If yes, an alarm or warning system will be activated or the system will take control of the vehicle (at 140) to guide it to a shoulder of the roadway or other safe location.

Detailed Description Text (292):
FIG. 12b is another flow chart of the method in accordance with the invention similar to FIG. 12a. Again the absolute position of the vehicle is determined at 130, e.g., using a GPS, DGPS PPS system, and compared to the location of a roadway yellow line at 142 (or possibly another line which indicates an edge of a lane of a roadway), which is obtained from a memory unit 132. Based on the comparison at 144, it is determined whether the absolute position of the vehicle is approaching close to or intersects the yellow line 144. If not, then the position of the vehicle is again obtained, e.g., at a set time interval thereafter, and the process continues. If yes, an alarm will sound or the system will take control of the vehicle (at 146) to control the steering or guide it to a shoulder of the roadway or other safe location.

Detailed Description Text (293):
FIG. 12c is another flow chart of the method in accordance with the invention similar to FIG. 12a. Again the absolute position of the vehicle is determined at 130, e.g., using a GPS, DGPS PPS system, and compared to the location of a roadway stoplight at 150, which is obtained from a memory unit 132. Based on the comparison at 150, it is determined whether the absolute position of the vehicle is approaching close to a stoplight. If not, then the position of the vehicle is again obtained, e.g., at a set interval thereafter, and the process continues. If yes, a sensor determines whether the stoplight is red (e.g., a camera) and if so, an alarm will sound or the system will take control of the vehicle (at 154) to control the brakes or guide it to a shoulder of the roadway or other safe location. A similar flow chart can be now drawn by those skilled in the art for other conditions such as stop signs, vehicle speed control, collision avoidance etc.

Detailed Description Text (294):
FIG. 13 illustrates an intersection of a major road 170 with a lesser road 172. The road 170 has the right of way and stop signs 174 have been placed to control the traffic on the lesser road 172. Vehicles 18 and 26 arc proceeding on road 172 and vehicle 25 is proceeding on road 170. A very common accident is caused when vehicle 18 ignores the stop sign 174 and proceeds into the intersection where it is struck in the side by vehicle 25 or strikes vehicle 25 in the side.

Detailed Description Text (298):
In another scenario where vehicle the 18 does properly stop at the stop sign, but vehicle 26 proceeds without observing the presence of the stopped vehicle 18, the laser radar, radar and camera systems will all operate to warn the driver of vehicle 26 and if that warning is not heeded, the system in vehicle 26 will automatically stop the vehicle 26 prior to its impacting vehicle 18. Thus, in the scenarios described above the "road to zero fatalities".TM. system and method of this invention will prevent common intersection accidents from occurring.

Detailed Description Text (300):
FIG. 15 illustrates the case where vehicle 18 is about to execute a left-hand turn into the path of vehicle 25. This accident will be prevented if both cars have the RtZF.TM. system since the locations and velocities of both vehicles 18,25 will be known to each other. If vehicle 25 is not equipped and vehicle 18 is, then the cam and laser radar subsystems will operate to prevent vehicle 18, turning into the path of vehicle 25. Thus, once again common intersection accidents are prevented by this invention.

Detailed Description Text (302):
An important part of this invention is the digital map that contains relevant information relating to the road on which the vehicle is traveling. The digital map usually includes the location of the edge of the road, the edge of the shoulder, the elevation and surface shape of the road, the character of the land beyond the road, trees, poles, guard rails, signs, lane markers, speed limits, etc. as discussed in more detail elsewhere herein. This data or information is acquired in a unique manner for use in the invention and the method for acquiring the information and its conversion to a map database that can be accessed by the vehicle system is part of the

invention. The acquisition of the data for the maps will now be discussed. It must be appreciated though that the method for acquiring the data and forming the digital map can also be used in other inventions.

Detailed Description Text (303):
Local area differential GPS can be utilized to obtain maps with an accuracy of 2 cm (one sigma). Temporary local differential stations are available from such companies as Trimble Navigation. These local differential GPS stations can be placed at an appropriate spacing for the road to be mapped, typically every 30 kilometers. Once a local differential GPS station is placed, it requires several hours for the station to determine its precise location. Therefore, sufficient stations are required to cover the area that is to be mapped within, for example, four hours. This may require as many as 10 or more such differential stations for efficient mapping.

Detailed Description Text (304):
A mapping vehicle 200, such as shown in FIGS. 16A, 16B and 17, is used and the mapping vehicle obtains its location from GPS satellites and its corrections from the local differential stations. Such a system is capable of providing the 2 cm accuracy desired for the map database. Typically, at least two GPS receivers 226 are mounted on the mapping vehicle 200. Each GPS receiver 226 is contained within or arranged in connection with a respective data acquisition module 202, which data acquisition modules 202 also contain a GPS antenna 204, an accurate inertial measurement unit (IMU) 206, a forward-looking video camera 208, a downward and outward looking linear array camera 210 and a scanning laser radar 212. The relative position of these components in FIG. 17 is not intended to limit the invention.

Detailed Description Text (305):
A processor including a printed circuit board 224 is coupled to the GPS receivers 226, the IMUs 206, the video cameras 208, the linear cameras 210 and the scanning laser radars 212. The processor receives information regarding the position of the vehicle from the GPS receivers 226, and optionally the IMUs 206, and the information about the road from both linear cameras 210 or from both laser radars 212, or from all of the linear cameras 210 and laser radars 212, and forms the road map database. Information about the road can also come from one or both of the video cameras 208 and be incorporated into the map database.

Detailed Description Text (307):
The data acquisition modules 202 are essentially identical and each mounts to the vehicle roof on an extension assembly 214 which extends forward of the front bumper. Extension assembly 214 includes a mounting bracket 216 from the roof of the vehicle 200 forward to each data acquisition module 210, a mounting bracket 218 extending from the front bumper upward to each data acquisition module 202 and a cross mounting bracket 220 extending between the data acquisition modules 202 for support. Since all of the data acquisition equipment is collocated, its precise location is accurately determined by the IMU and the differential GPS system.

Detailed Description Text (308):
The forward-looking video cameras 208 provide views of the road as shown in FIG. 18. These cameras 208 permit the database team to observe the general environment of the road and to highlight any anomalies. They also permit the reading of traffic signs and other informational displays all of which will be incorporated into the database. The cameras 208 can be ordinary color video cameras, high-speed video cameras, wide angle or telescopic cameras, black and white video cameras, infrared cameras, etc. or combinations thereof. In some cases, special filters are used to accentuate certain features. For example, it has been found that lane markers frequently are more readily observable at particular frequencies, such as infrared. In such cases, filters can be used in front of the camera lens or elsewhere in the optical path to block unwanted frequencies and pass desirable frequencies. Polarizing lenses have also been found to be useful in many cases. Normally, natural illumination is used in the mapping process, but for some particular cases, particularly in tunnels, artificial illumination can also be used in the form of a floodlight or spotlight that can be at any appropriate frequency of the ultraviolet, visual and infrared portions of the electromagnetic spectrum or across many frequencies. Laser scanners can also be used for some particular cases when it is desirable to illuminate some part of the scene with a bright spot. In some cases, a scanning laser rangefinder can be used in

conjunction with the forward-looking cameras 204 to determine the distance to particular objects in the camera view.

Detailed Description Text (309):
The video camera system can be used by itself with appropriate software as is currently being done by Lamda Tech International Inc. of Waukesha, Wis., to obtain the location of salient features of a road. However, such a method to obtain accurate maps is highly labor intensive and therefore expensive. The cameras and associated equipment in the present invention are therefore primarily used to supplement the linear camera and laser radar data acquisition systems to be described now.

Detailed Description Text (311):
The linear camera 210 is a device that typically contains a linear CCD, CMOS or other light sensitive arrays of, for example, four thousand pixels. An appropriate lens provides a field of view to this camera that typically extends from approximately the center of the vehicle out to the horizon. This camera records a one-dimensional picture covering the entire road starting with approximately the center of the lane and extending out to the horizon. This linear array camera 210 therefore covers slightly more than 90 degrees. Typically, this camera operates using natural illumination and produces effectively a continuous picture of the road since it obtains a linear picture, or column of pixels, for tropically every one inch of motion of the vehicle. Thus, a complete two-dimensional panoramic view of the road traveled by the mapping vehicle is obtained. Since there are two such measurement units, a 180 degree view is obtain This camera will typically record in full color thus permitting the map database team to have a complete view of the road looking perpendicular from the vehicle. The view is recorded in a substantially vertical plane. This camera will not be able to read text on traffic signs, thus the need for the forward-looking cameras 208. Automated software can be used with the images obtained from these cameras to locate the edge of the road, lane markers, the character of land around and including the road and all areas that an errant vehicle may encounter. The full color view allows the characterization of the land to be accomplished automatically with minimal human involvement.

Detailed Description Text (313):
For each scan, the laser radar 212 provides the distance from the scanner to the ground for up to several thousand points in a vertical plane extending from approximately the center of the lane out to near the horizon. This device therefore provides precise distances and elevations to all parts of the road and its environment. The precise location of signs that were observed with the forward-looking cameras 204, for example, can now be easily and automatically retrieved. The scanning laser radar therefore provides the highest level of mapping automation.

Detailed Description Text (314):
Scanning laser radars have been used extensively for mapping purposes from airplanes and in particular from helicopters where they have been used to map portions of railway lines in the United States. This is the first known use of the scanning laser radar system for mapping roadways where the radar is mounted onto a vehicle that is driving the road.

Detailed Description Text (318):
A particularly important enhancement to the above-described system uses precise positioning technology independent of GPS. The precise positioning system, also known as the calibration system, generally permits a vehicle to precisely locate itself independently of the IMU or DGPS systems.

Detailed Description Text (319):
One example of this technology involves the use of a radar and reflector system wherein radar transceivers are placed on the vehicle that send radar waves to reflectors that are mounted at the side of road. The location of reflectors either is already precisely known or is determined by the mapping system during data acquisition process. The radar transceivers transmit a pulse or frequency modulated radar signal to the road-mounted reflectors, typically corner reflectors, which reflect a signal back to the radar transceiver. This permits the radar system to determine the precise distance from the transceiver to the reflector by either time-of-flight or phase methods.

Detailed Description Text (320):
In one possible implementation, each vehicle is equipped with two radar devices operating in the 24-77 GHz spectrum. Each radar unit will be positioned on the vehicle and aimed outward, slightly forward and up toward the sides of the roadway. Poles would be positioned along the roadway at appropriate intervals and would have multiple corner cube radar reflectors mounted thereon to thereto, possibly in a vertical alignment. The lowest reflector on the pole would be positioned so that the vehicle radar will illuminate the reflector when the vehicle is in the lane closest to the pole. The highest reflector on the pole would be positioned so that the vehicle radar will illuminate the reflector when the vehicle is in the lane most remote from the pole. The frequency of the positioning of the poles will be determined by such considerations as the availability of light poles or other structures currently in place, the probability of losing access to GPS satellites, the density of vehicle traffic, the accuracy of the IMU and other similar considerations. Initially rough calculations have found that a spacing of about 1/4 mile would likely be acceptable.

Detailed Description Text (321):
If the precise location of the reflectors has been previously determined and is provided on a road map database, then the vehicle can use this information to determine its precise location on the road. In the more typical case, the radar reflectors are installed and the mapping vehicle knows its location precisely from the differential GPS signals and the IMU, which for the mapping vehicle is typically of considerably higher accuracy then will be present in the vehicles that will later use the system. As a result, the mapping vehicle can also map a tunnel, for example, and establish the locations of radar reflectors that will later be used by non-mapping vehicles to determine their precise location when the GPS and differential GPS signals are not available. Similarly, such radar reflectors can be located for an appropriate distance outside of the tunnel to permit an accurate location determination to be made by a vehicle until it acquires the GPS and differential GPS signals. Such a system can also be used in urban canyons and at all locations where the GPS signals can be blocked or are otherwise not available. Since the cost of radar reflectors is very low, it is expected that eventually they will be widely distributed on the 4 million miles of roads in the U.S.

Detailed Description Text (325):
The operation of the system is as follows. A vehicle traveling down a roadway in the vicinity of the reflector poles would transmit radar pulses at a frequency of perhaps once per millisecond. These radar pulses would be encoded so that each vehicle knows exactly what radar returns are from its transmissions. As the vehicle approaches a reflector pole, it will begin to receive reflections based on the speed of the vehicle. By observing a series of reflections, the vehicle software can select either the maximum amplitude reflection or the average or some other scheme to determine the proper reflection to consider. The radar pulse will also be modulated to permit a distance to the reflector calculation to be made based on the phase of the returned signal. Thus, as a vehicle travels down the road and passes a pair of reflector poles, it will be able to determine its longitudinal position on the roadway based on the pointing angle of the radar devices and the chosen maximum return as described above. It will also be able to determine its lateral position on the roadway based on the measured distance from the radar to the reflector.

Detailed Description Text (327):
To summarize this aspect of the invention, an inexpensive infrastructure installation concept is provided which will permit a vehicle to send a radar pulse and receive a reflection wherein the reflection is identifiable as the reflection from the vehicle's own radar and contains information to permit an accurate distance measurement. The vehicle can thus locate itself accurately longitudinally and laterally along the road.

Detailed Description Paragraph Table (1):
Horizontal Error (m) Vertical Error (m) (50%) (95%) (95%) GPS (SA off) 7 18 34 GPS (SA on) 27 72 135 GLONASS 10 26 45 GPS + GLONASS 9 20 38

Other Reference Publication (1):
SRI International, Centimeter-Level GPS for Highway Systems, J.W. Sinko et al., Jul.

1998.

Other Reference Publication (2):
SRI International, An Evolutionary Automated Highway System Concept Based on GPS, J.W. Sinko, Sep., 1996 (p. 5, second column to p. 7).

Other Reference Publication (3):
SRI International, Using GPS for Automated Vehicle Convoying, T.M. Nguyen, Sep. 1998.

Other Reference Publication (5):
V. Morellas et al., Preview Based Control of a Tractor trailer Using DGPS for Preventing Road Departure Accidents, 1998 IEEE International Conference on Intelligent Vehicles, pp. 797-805.

Other Reference Publication (6):
S. Bajikar et al., Evaluation of In-Vehicle GPS-Based Lane Position Sensing for Preventing Road Departure, 1998 IEEE International Conference on Intelligent Vehicle, pp. 397-402.

Other Reference Publication (19):
Lambda Tech Asset Inventory & Digital Mapping Systems, Capturing Road and Railway Network Data Using Mobile Mapping Technology, The GPSVision.TM. System.

CLAIMS:

1. An arrangement for attaching to a vehicle to enable mapping of a road during travel of the vehicle, comprising: a first data acquisition module adapted to be arranged on a first side of the vehicle; a second data acquisition module adapted to be arranged on a second side of the vehicle; each of said modules comprising a GPS receiver and an antenna for enabling a determination of the position of the vehicle to be obtained and a linear camera adapted to provide one-dimensional images of an area on a respective one of the first and second sides of the vehicle, said linear cameras providing images of a vertical plane perpendicular to the road such that a view of the road in a direction perpendicular to the road is obtained and information about the road is obtainable from that view; and processor means coupled to said modules for forming a map database of the road by correlating the position of the vehicle on the road and the information about the road.

3. The arrangement of claim 1, wherein said linear camera in each of said modules comprises a lens for providing a field of view from an approximate center of the vehicle to the horizon whereby said linear cameras are adapted to record one-dimensional pictures covering the entire road starting with approximately the center of a lane in which the vehicle travels and extending out to the horizon.

4. The arrangement of claim 1, wherein each of said modules further comprises a scanning laser radar adapted to transmit waves downward in a plane perpendicular to the road and receive reflected radar waves to thereby provide information about distance between said laser radar and the ground which constitutes information about the road.

7. The arrangement of claim 1, wherein each of said modules further comprises a video camera adapted to provide images of an area in front of the vehicle whereby images of an environment of the road including traffic signs and other informational displays are obtained and provide information about the road.

10. The arrangement of claim 9, wherein said means for providing artificial illumination comprise a laser scanner adapted to illuminate a particular part of the area in front of the vehicle with a bright spot.

11. The arrangement of claim 7, further comprising a scanning laser rangefinder arranged in connection with at least one of said video cameras for determining the distance to particular objects in the images obtained by said at least one video camera whereby the distance constitutes information about the road.

14. The arrangement of claim 13, wherein said mounting assembly comprises a mounting

bracket for attaching each of said modules to a roof of the vehicle, a mounting bracket for attaching each of said modules to a front of the vehicle and a mounting bracket for connecting said modules together.

15. An arrangement for attaching to a vehicle to enable mapping of a road during travel of the vehicle, comprising: a first data acquisition module adapted to be arranged on a first side of the vehicle; a second data acquisition module adapted to be arranged on a second side of the vehicle; each of said modules comprising a GPS receiver and an antenna for enabling a determination of the position of the vehicle to be obtained and a scanning laser radar adapted to transmit waves downward in a plane perpendicular to the road and receive reflected radar waves to thereby provide information about distance between said laser radar and the ground which constitutes information about the road; and processor means coupled to said modules for forming a map database of the road by correlating the position of the vehicle on the road and the information about the road.

16. The arrangement of claim 15, wherein each of said modules further comprises a linear camera adapted to provide one-dimensional images of an area on a respective one of the first and second sides of the vehicle, said linear cameras providing images of a vertical plane perpendicular to the road such that a view of the road in a direction perpendicular to the road is obtained and information about the road is obtained from that view.

18. The arrangement of claim 16, wherein said linear camera in each of said modules comprises a lens for providing a field of view from an approximate center of the vehicle to the horizon whereby said linear cameras are adapted to record one-dimensional pictures covering the entire road starting with approximately the center of a lane in which the vehicle travels and extending out to the horizon.

21. The arrangement of claim 15, wherein each of said modules further comprises a video camera adapted to provide images of an area in front of the vehicle whereby images of an environment of the road including traffic signs and other informational displays are obtained and provide information about the road.

24. The arrangement of claim 23, wherein said means for providing artificial illumination comprise a laser scanner adapted to illuminate a particular part of the area in front of the vehicle with a bright spot.

25. The arrangement of claim 21, further comprising a scanning laser rangefinder arranged in connection with at least one of said video cameras for determining the distance to particular objects in the images obtained by said at least one video camera whereby the distance constitutes information about the road.

28. The arrangement of claim 27, wherein said mounting assembly comprises a mounting bracket for attaching each of said modules to a roof of the vehicle, a mounting bracket for attaching each of said modules to a front of the vehicle and a mounting bracket for connecting said modules together.

29. A method for mapping a road, comprising the steps of: arranging a first data acquisition module on a first side of the vehicle; arranging a second data acquisition module on a second side of the vehicle, each of the modules comprising a GPS receiver and an antenna and a linear camera oriented to provide one-dimensional images in a vertical plane of an area on a respective one of the first and second sides of the vehicle; operating the vehicle on the road while continually obtaining the position of the vehicle using the GPS receiver and antenna and obtaining images from the linear cameras of vertical planes perpendicular to the road; and forming a map database of the road by correlating the position of the vehicle on the road and information about the road obtained from the images from the linear cameras.

30. The method of claim 29, further comprising the step of arranging a lens in connection with each of the linear cameras to provide a field of view from an approximate center of the vehicle to the horizon whereby the video cameras obtain one-dimensional images covering the entire road starting with approximately the center of the road on which the vehicle travels and extending out to the horizon.

31. The method of claim 29, further comprising the steps of: arranging a scanning laser radar in each of the modules; and while operating the vehicle, transmitting waves from the laser radars downward in a plane perpendicular to the road and receiving reflected radar waves to thereby provide information about distance between the laser radars and the ground which constitutes information about the road for use in formation of the map database.

33. The method of claim 29, further comprising the steps of: arranging a video camera in each of the modules to provide images of an area in front of the vehicle including traffic signs and other informational displays; and while operating the vehicle, obtaining images from the video cameras to thereby provide information about the road for use in formation of the map database.

35. A method for mapping a road, comprising the steps of: arranging a first data acquisition module on a first side of the vehicle; arranging a second data acquisition module on a second side of the vehicle; each of the modules comprising a GPS receiver and an antenna and a scanning laser radar oriented to transmit waves downward in a plane perpendicular to the road and receive reflected radar waves; operating the vehicle on the road while continually obtaining the position of the vehicle using the GPS receiver and antenna and obtaining information about the distance between the laser radars and the ground by transmitting and receiving radar waves; and forming a map database of the road by correlating the position of the vehicle on the road and the information about distance between the laser radars and the ground.

36. The method of claim 35, further comprising the steps of: arranging a linear camera in each of the modules; positioning the linear cameras oriented to provide one-dimensional images of a vertical plane of an area on a respective one of the first and second sides of the vehicle; and while operating the vehicle, obtaining one-dimensional images from the linear cameras to thereby provide information about the road from the images for use in formation of the map database.

37. The method of claim 36, further comprising the step of arranging a lens in connection with each of the linear cameras to provide a field of view from an approximate center of the vehicle to the horizon whereby the video cameras obtain one-dimensional images covering the entire road starting with approximately the center of the road on which the vehicle travels and extending out to the horizon.

39. The method of claim 25, further comprising the steps of: arranging a video camera in each of the modules to provide images of an area in front of the vehicle including traffic signs and other informational displays; and while operating the vehicle, obtaining images from the video cameras to thereby provide information about the road for use in formation of the map database.

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DOCUMENT-IDENTIFIER: US 6199001 B1
TITLE: Control system for controlling the behavior of a vehicle based on accurately detected route information

Abstract Text (1):
A control system for a vehicle includes a route information detector, which detects route information for the vehicle, and behavior control system, which is controlled by the route information detector and which controls the behavior of the vehicle. The control system also includes a means for detecting the accuracy of the detection of the route information, and a changing controller which changes the control of the behavior control system based on the accuracy of the detection of the route information. In this case, the behavior control system can be a transmission, a suspension system, a brake system, a steering system, an engine, or an auto drive control system. The behavior control system is controlled by control patterns that can be changed by a changing controller.

Brief Summary Text (3):
This invention is directed to a control device for a vehicle, which controls the behavior of the vehicle based on information regarding the route that the vehicle follows. This information is output by a route information detector.

Brief Summary Text (5):
Generally a vehicle has a behavior control system, for example, an engine or a transmission. Control patterns applied to the behavior control system are either manually selected by the driver or automatically based on selected driving conditions detected by various sensors. But, both ways of selecting the control patterns are executed after encountering an actual vehicle condition change, hence behavior controls of the vehicle are delayed relative to actual road conditions, so it is possible to make the drivability of the vehicle worse.

Brief Summary Text (6):
Recently, it has become possible for a route information detection system, for example, a navigation system, to detect in advance information regarding the road conditions on which the vehicle travels, and this information is used to control the control patterns which are applied to the engine and automatic transmission in order to control the behavior of the vehicle as desired. An example of a vehicle control system is disclosed in Japanese Laid Open Publication No. HEI 8-72591.

Brief Summary Text (7):
In the above mentioned application, the vehicle control system for a vehicle has a location detection means, which detects the present location of the vehicle, a operating road predicting means, which predicts the future location of the vehicle in a few seconds later by referring to an electronic map, a running resistance measuring means, which measures the present load condition of driving systems of the vehicle, a driving force predicting means, which predicts the driving force at the predicted future location of the vehicle by correcting the present load condition on the basis of slope information from the electronic map, a driving system control unit, which controls in advance either the engine or the automatic transmission in order to get sufficient driving force of the predicted driving force to correspond and furthermore to reduce fuel consumption as much as possible, and a running locus recording means, which detects the information on the vehicle speed, and records and accumulates this information in the electronic map.

Brief Summary Text (8):
According to the above mentioned control system, by controlling the engine or the automatic transmission to get a predicted driving force, which corresponds to the condition of future location of the vehicle, and which is determined by the driving force predicting means, the vehicle is able to maintain the appropriate driving force for the road condition. Furthermore, it improves the drivability on an actual road condition by reflecting the driver's intention to the control of the driving force.

Brief Summary Text (9):
In the above mentioned control system of the vehicle, because the route information is detected on the basis of radio waves from man-made satellites and the signals from various sensors, if the vehicle operates in places where the radio waves barely reach or the sensors fail, it is possible not to detect the correct route. As a result, the problem arises that the driving force of the vehicle is inappropriate to the road condition and the drivability deteriorates.

Brief Summary Text (11):
Although, it is possible that the outputted information includes an error within a certain degree, even if the running information output means, which outputs the information, is operating normally. Under this circumstance, if the predetermined moving condition control, which is appropriate to the fail condition of the information output means, is executed, the moving condition of the vehicle does not adapt to the road condition. As a result, it is possible that the drivability deteriorates.

Brief Summary Text (14):
One object of the present invention is to provide a control system for a vehicle that is able to control the behavior of the vehicle precisely based on the accuracy of detected route information.

Brief Summary Text (15):
A control system built according to the present invention is described in the following. The control system defines the accuracy of information detected by the navigation system, and changes the control patterns which are applied to the behavior control system corresponding to the detected accuracy of the route information. At least one of the following defines the accuracy of detected of the route information; the location of the vehicles position, detected by a first data detecting unit and a second data detecting unit of a navigation system, and map data stored in the data recording medium of the navigation system, are compared with each other to determine the accuracy of the route information; the location ,the present vehicle position by the first data detecting unit and the second data detecting unit or the map data stored in the data recording medium, are compared with each other to determine the accuracy of the route information detected by the second data detecting unit or the map data stored in the recording medium; the place where the vehicle is operating determines the accuracy of the route information detected by the second data detecting unit by itself; the map data stored in the recording medium determines the accuracy of the route information detected by the first data detecting unit and the second data detecting unit; or the map matching condition detects the accuracy of the route information.

Brief Summary Text (16):
At least one of the following changes the control patterns which are applied to the control of the behavior control system corresponding to the accuracy of the route information; according to the accuracy of corner information, the automatic transmission is down shifted; according to the accuracy of down slope information, the automatic transmission is prohibited from shifting up; according to the accuracy of climbing road information, the automatic transmission changes its shift pattern of the shift diagram to the power pattern; according to the accuracy of down slope information, the brake system is controlled by its oil pressure; according to the accuracy of congestion information, the vehicle auto drive control is canceled or initiated; according to the accuracy of the surface condition of the road, the damping force of the suspension is changed; according to the accuracy of the surface condition of the road, the power assist of the steering wheel is changed; according to the accuracy of congestion, the engine is controlled to decrease its fuel consumption.

Brief Summary Text (17):
According to invention, the control patterns which are applied to the control of the behavior control system, which include, the engine control, the transmission control, and the suspension control, the brake control, the steering control, the vehicle auto drive control, are changed corresponding to the accuracy of the route information, which is detected by an information detection device. So, it is possible to precisely control and conform the behavior of the vehicle to the actual driving route condition. Thus, the capability of the power train, the stability and controllability, drivability, and comfort are improved.

Drawing Description Text (7):
FIG. 6 is a block diagram showing an example of a navigation system to which is applied the control system of the present invention.

Detailed Description Text (2):
The entire disclosure of Japanese Patent Application HEI 8-354518 filed on Dec. 19, 1996 and HEI 8-355567 filed on Dec. 24, 1996 including specification, claims drawings and summary are incorporated herein by reference in their entirety. The present invention will be described more specifically with reference to the accompanying drawings. First of all, here will be described the summary of a vehicle to which is directed the present embodiment. In FIG. 1, there is connected to the output side of an engine 1 acting as a power source, an automatic transmission 2, which is exemplified by transmission gear stages. The output power of the engine 1 is electrically controlled, and an intake manifold 3 of the engine 1 is provided with an electronic throttle valve 5, which is driven by a servo motor 4. The engine 1 is provided with a fuel injection control unit 6, including a fuel injector 6A, which controls the amount of the fuel injection in the combustion chamber 1A, and an ignition timing adjusting unit 7, including a spark plug 7A, a distributor 7B, and an ignition coil 7C. An opening amount of an acceleration pedal 8, which is used to control the output power of the engine 1, is detected by an acceleration pedal switch 9. The acceleration pedal switch 9 generates a signal indicative of the operating amount of the acceleration pedal 8, which is applied to the engine electronic control unit (E-ECU) 10. The engine electronic control unit 10 is comprised of a micro computer, which incorporates a central processing unit CPU) 11, a random-access memory (RAM) 12, an input interface circuit 13, and an output interface circuit 14. The engine electronic control unit 10 is fed with various kinds of data to control the engine 1, for example, data from an engine revolving speed sensor 15 for detecting the revolving speed of the engine (Ne), data from an air flow meter 16 for detecting the quantity of intake-air (Q), an intake-air temperature sensor 17 for detecting the temperature of intake air, and a throttle sensor 18 for detecting the opening degree.THETA. of the electronic throttle valve 5. Furthermore, the engine electronic control unit 10 is fed with data from a vehicle speed sensor 19 for detecting vehicle velocity in accordance with the revolving speed of the output shaft of the automatic transmission 2 or the like, cooling water temperature sensor 20 for detecting the temperature of cooling water for the engine 1, and a brake switch 22 for detecting the amount of the operation of brake pedal 21. The engine electronic control unit (E-ECU) 10 calculates data, which are from various sensors and switches, in order to determine the operating condition of the vehicle. At least one of the following is controlled based on the operating condition: opening of the electronic throttle valve 5, the amount of the fuel injection of the fuel injection control unit 6, or the ignition timing of the ignition control unit 7. The engine electronic control unit (E-ECU) 10 and navigation systems are connected to communicate with each other to exchange data. It is possible that the engine electronic control unit (E-ECU) 10 controls at least one of the opening of the electronic throttle valve 5, the amount of the fuel injection of the fuel injection control unit 6, or the ignition timing of the ignition control unit 7 based on the route data output from the navigation system, which indicates the route that the vehicle will follow. So the engine electronic control unit (E-ECU) 10 stores the standard data, which will be corrected by correspondence of the road information to the route, to control the opening of the electronic throttle valve 5, the amount of the fuel injection of the fuel injection control unit 6, or the ignition timing of the ignition control unit 7.

Detailed Description Text (12):
The transmission electronic control unit (E-ECT) 55 and a navigation system which will

be explained lately, are connected to communicate with each other. The navigation system sends signals, for example, data about the operating route. The transmission electronic control unit (E-ECT) 55 controls the automatic transmission 2 on the basis of the signals from the navigation system. The transmission electronic control unit 55 stores the standard data and the procedures of the calculations in order to control the automatic transmission 2 in accordance with the condition of the operating route.

Detailed Description Text (14):
FIG. 4 shows an example of a map of shift boundary lines applied to the control of the automatic transmission 2. This map of the shift boundary lines are predetermined on the basis of a an operating speed V of the vehicle and the opening amount of the accelerate pedal. The example in FIG. 4 shows shift up boundary lines corresponding to the economy pattern, the normal pattern, and the power pattern. The shift boundary H1 of the economy pattern is set lower speed side of the shift boundary H2 of the normal pattern, the shift boundary H3 of the power pattern is set on the higher speed side of the shift boundary H2 of the normal pattern. Furthermore, it is possible to set the shift map for the snow pattern which always sets the second gear stage when the vehicle starts to go. The selection of the shift patterns is executed by the drivers operation of the select pattern switch 61. And it is possible to select the shift map automatically on the basis of route information which is detected by the navigation system. The means for selecting the shift map automatically incorporates the means for storing plural shift maps in the transmission electronic control units 55, the means for reading one of the shift maps, and the means for controlling the automatic transmission based on the selected map. It is possible to use the means for correcting the standard map by calculating on the basis of the information pattern, and to control the automatic transmission based on the corrected shift map.

Detailed Description Text (15):
As shown in FIG. 1, a vehicle control system has a brake system 65, a vehicle auto drive control system 66, a suspension system 67, a steering system 68, a lighting system 69, and a navigation system 70. As shown in FIG. 5, the brake system 65 includes a brake pedal 21 which is operated by the driver, a brake switch 22 for detecting the amount of the operation of the brake pedal 21, and a master cylinder 71 which converts the operation power of the brake pedal 21 into the oil pressure. The brake system 65 has a wheel cylinder 72 to which is delivered the oil pressure electrically, wheel sensors 74 detect the revolving speed of each wheel individually , and the electronic control system 75, which controls these elements on the basis of the operation of the brake pedal 21 and the driving condition of the vehicle.

Detailed Description Text (17):
The brake system 65 and the navigation system 70 are connected to communicate with each other. It is possible to adapt the braking force by controlling the oil pressure to the wheel cylinders 72 on the basis of the information about the operating route detected by the navigation system 70. The electronic control system 75 stores the standard data and the procedures of the calculations in order to control the automatic transmission 2 in accordance with the condition of the operating route.

Detailed Description Text (18):
The vehicle auto drive control system 66 controls the engine 1 and the automatic transmission 2 in order to control the vehicle speed automatically. The vehicle auto drive control system 66 has a control switch 76 for setting the vehicle speed, a cancellation switch 77 for canceling the vehicle auto drive control, a vehicle speed sensor 19 for detecting the vehicle speed, an electrically controlled throttle valve 5 provided in the intake manifold 3 of the engine 1, an electronic throttle valve 5 which is driven by an servo motor 4, and an electrical control system 75 for controlling these elements on the basis of the selected vehicle speed and the operating condition of the vehicle. An operation signal from the control switch 76 of the vehicle auto drive control system 66 is sent to the engine electronic control unit (E-ECT) 10 and the transmission electronic control unit (T-ECT) 55. These units control the amount of the opening of the electronic throttle valve 5 at the specific condition and the gear stage without the operation of the acceleration pedal 8. Consequently the speed of the vehicle is fixed. The vehicle auto drive control system 66 cancels the automatic speed control by detecting at least one of the operations, acceleration pedal 8 movement, brake pedal 21 movement, or shift lever 53 movement of the automatic transmission 2. The vehicle auto drive control system 66 and the

navigation system 70, which will be explained later, are connected to communicate with each other. The navigation system 70 sends signals, for example, data about the operating route. It is possible to start or cancel the automatic speed control on the basis of the information on the operating route from the navigation system 70. The electronic control system 78 stores the standard data and the procedures of the calculations in order to control the vehicle auto drive control system 66 in accordance with the condition of the operating route.

Detailed Description Text (20):
The suspension system 67 improves the stability and controllability, and comfort by controlling damping force of the shock absorbers 79 and the air springs 80; damping force is controlled by the electronic control unit 82. The suspension system 67 and the navigation system are connected to communicate with each other. It is possible to control the damping force of the shock absorbers 79 and the air springs 80 on the basis of the signals from the navigation system 70.

Detailed Description Text (22):
The steering system 68 and the navigation system are connected to communicate with each other. It is possible to control the oil pressure of the gear box 85 on the basis of the signals from the navigation system 70 and improve the operability of the steering wheel 83.

Detailed Description Text (24):
The following navigation system 70 is provided for improving the stability, drivability and power performance of the vehicle by feeding data and the instruction signals to the aforementioned transmission electronic control unit 55, the engine electronic control unit 10, the brake system 65, and the vehicle auto drive control system 66. The navigation system 70 guides its vehicle to a predetermined target. This navigation system 70 is equipped, as shown in FIG. 5, with an electronic control unit 95, a first data detecting unit 96, a second data detecting unit 97, a player 98, a multiple audio visual system 99, and a speaker 100.

Detailed Description Text (25):
The electronic control unit 95 is a microcomputer which includes a central processing unit (CPU), a memory unit (RAM and ROM) 83, input interface 84, and output interface 85. The player 79 is used for reading out data which is stored in a data recording medium 105, for example, an optical disk or a magnetic disk. The data recording medium 105 stores not only data necessary for driving the vehicle, for example, place names, roads or main buildings along the roads but also specific road situations, for example, straight roads, curves, up slopes, down slopes gravel roads, sandy beaches, riverbeds, urban areas, mountain regions, ordinary roads, expressways, rivers, seas, paved or unpaved roads, rough or smooth roads, road signs, and traffic regulations.

Detailed Description Text (26):
FIG. 6. Shows one of the examples; the road data are digitized and stored in the data recording medium 105. Specifically, the road map is divided in a mesh shape, and each mesh is composed as a unit of nodes 87, and links 88 joining the nodes 87. The stored contents are attributes of the links 88 joining the nodes 87, for example, the latitudes and longitudes of roads, road numbers, road width, distance of straight roads, road slopes and radii of curves.

Detailed Description Text (27):
The aforementioned first data detecting unit 22 is used to detect the present position of its vehicle, the road situations and the distance from other vehicles by the self-contained navigation, and is composed of a geomagnetic sensor 106 for detecting the azimuth for driving the vehicle, a gyrocompass 107, and a steering sensor 108 for detecting the steering angle of the steering wheel 83.

Detailed Description Text (28):
The first data detecting unit 96 is equipped with a slope sensor for detecting the slopes of roads, a video camera 110 for recognizing a front vehicle and detecting the distance therefrom, a laser cruise unit 111, a distance sensor 112, a wheel speed sensor 74 for detecting the rotational speeds of the individual wheels separately, an acceleration sensor 113 for detecting the acceleration of the vehicle in all directions and a vehicle speed sensor 19 for detecting the revolving speed of the

output shaft of the transmission. Here, the laser cruise unit 111 controls the throttle opening to keep a set vehicle speed when the front vehicle is not detected by the laser radar or when the distance from the front vehicle is sufficiently large.

Detailed Description Text (29):
The first data detecting unit 96 and the electronic control unit 95 are connected to transmit data so that data, as detected by the first data detecting unit 96, is transferred to the electronic control unit 95. The second data detecting unit 97 detects the present position of its vehicle, the road situations, other vehicles, blocks and the weather, and is composed of a GPS antenna 115 for receiving radio waves from a man-made satellite 114, an amplifier 116 connected with the GPS antenna 115, and a GPS receiver 117 connected with the amplifier 116. The second data detecting unit 97 is equipped with an antenna 119 for receiving radio waves from a ground data transmission system 118 such as a transmitter carried on another vehicle, a beacon or sign post disposed on the road side, a VICS (Vehicle Information & Communication System) or an SSVS (Super Smart Vehicle System), an amplifier 120 connected with the antenna 119, and a ground data receiver 121 connected with the amplifier 45.

Detailed Description Text (30):
The GPS receiver 117 and the ground data receiver 121 are so connected with the electronic control unit 95 as to effect data communications. Data, as detected by the second data detecting unit, are transferred to the electronic control unit 95.

Detailed Description Text (31):
The multiple audio visual system 99 has a display 122 which consists of a liquid crystal display or a cathode-ray tube (CRT) and various switches. The multiple audio visual system 99 displays data graphically, for example, the road to follow to the destination, the road situations of the roads, the present position of the vehicle, the presence and location of other vehicles, or the presence and location of blocks, and displays the operating modes corresponding to the predetermined sections of the road situations and the shift diagrams to be used for controlling the automatic transmission 2 on the basis of data stored in the data recording medium 105 or first and second data detecting unit 96 and 97. Incidentally, the various data are displayed in the display 106 and outputted as voices from the speaker 100.

Detailed Description Text (32):
With the multiple audio visual system 99, there are connected a various switches 107, which can be operated to control the first data detecting unit 96 or the second data detecting unit 97, to set the destination and the road to follow, to set or change the predetermined sections in the roads, to enlarge or reduce the size of the map, and to display and change the shift map to be applied for controlling the automatic transmission 2.

Detailed Description Text (33):
In the navigation system 70, data of the road which the vehicle will follow, as detected by the first data detecting unit 96, as detected by the second data detecting unit 97, and the map data, as stored in the data recording medium 105 are synthetically compared or evaluated to determine the road situations of or round the present position of the vehicle on the route being followed The result of the comparison, the road situation, is indicated in the display 106 or the speaker 100.

Detailed Description Text (35):
The followings are examples of this invention. One control example judges the accuracy of detection of the route information detected by the navigation system 70, and the other example changes the control patterns which are applied to the control of the behavior control system corresponding to the accuracy of the route information.

Detailed Description Text (36):
Examples of control flows disclosed in FIGS. 7 to 11 include the means for detecting the accuracy of the detection of the route information. The control flow in FIG. 7 judges the accuracy of the route information by comparing the location of the present vehicle position, detected by the first data detecting unit 96 and the second data detecting unit 97, and the map data stored in the data recording medium 105.

Detailed Description Text (37):

First of all, at Step 1, the driver's operation for the setting the destination and the indication of the map of the route is executed by using the switches 123 of the multiple audio visual system 99. The present position of the vehicle and the road ahead of the present position can be specified by data of the first data detecting unit 96 and the second data detecting unit 97.

Detailed Description Text (39):
If the answer of Step 2 is NO, the control flow goes to Step 3, the distance L between the present location of the vehicle and the nearest road is calculated. At Step 4, it is decided whether the distance determined at Step 3 is smaller than the predetermined value. If the answer of Step 4 is NO, the control flow goes to Step 5, because the accuracy of detection of the route information is better than a predetermined degree, a flag is turned OFF, which flag in the ON state indicates the poor accuracy of the detection of the first data detecting unit 96 and the second data detecting unit 97, and control flow returns. If the answer of the Step 2 is YES or the answer of the Step 4 is NO, the control flow goes to Step 6, because the map data stored in the recording medium 105 has a priority over the first data detecting unit 96 and the second data detecting unit 97, the accuracy of the detection of the first data detecting unit 96 and the second data detecting unit 97 are poor, and flag is turned ON. This flag indicates the poor accuracy of the detection. And the control flow returns. Steps 2, 3, 4, 5, and 6 corresponding to the means for detecting accuracy of the detection of the information.

Detailed Description Text (40):
Examples of the control flow shown in FIG. 8 judge the accuracy of the route information detected by the second data detecting unit 97 or the map data stored in the recording medium 105 by comparing the location of the present vehicle position, detected by the first data detecting unit 96, and the second data detecting unit 97, or the map data stored in the data recording medium 105.

Detailed Description Text (41):
At Step 11, the same control is executed in Step 1 in FIG. 1. At Step 12, it is decided whether the vehicle be now running in the curved area, such as a, curve, corner, or winding road, based on the information detected by second data detecting unit 97 or the first data detecting unit 96. If the answer of Step 12 is YES, the control flow goes to Step 13. It is decided whether the actual steering wheel angle by the steering sensor 108 exceeds a predetermined value. In other words, if the vehicle is actually running in the curved area, the steering wheel angle inevitably changes. So data detected by the steering sensors 108 are regarded as the standard, and the accuracy of data of the second data detecting unit 97 or the map data in the data recording medium are determined on the basis of the standard data.

Detailed Description Text (43):
If the answer of Step 12 is NO, the control flow goes to Step 15, when it is decided whether the actual steering wheel angle by the steering sensor 108 exceed a predetermined value. When the answer of Step 15 is YES, even if the vehicle is actually running in the curved area and the steering wheel angle exceeds more the predetermined value, and neither the data from the second data detecting unit 97 nor the map data in the data recording medium does not indicate the curve condition, in such a case, the control flow goes to Step 14. Furthermore, if the answer of Step 15 is NO, data of the steering wheel angle detected by the steering sensor 108 and data of the second data detecting unit 97 or the map data in the data recording medium 105 matches. At Step 16, the flag, which indicates that data detected by the second data detecting unit 97 or data stored in the recording medium are poor, is turned OFF. And the control flow returns. If the answer of Step 13 is YES, it is decided that the vehicle is running on a gentle curved road, and the control flow goes to Step 16. Steps 12, 13, 14, 15, and 16 corresponding to the means for detecting the accuracy of the detection of the information.

Detailed Description Text (44):
The following are other examples which compare data detected by the first data detecting unit 96 and data detected by the second data detecting unit 97 or stored in the recording medium 105, and judge the accuracy of data by the second data detecting unit 97 or data in the recording medium 105. While the vehicle is running a curve, the lateral acceleration surpasses a predetermined value, and the difference of the

revolution speed of the right and left wheels surpasses a predetermined value. So, by comparing data detected by the acceleration sensor 117, the wheel revolution at speed sensors 74, and data detected by the second data detecting unit 97 or in the recording medium, it is possible to judge the accuracy of data detected by the second data detecting unit 97 or stored in the recording medium. While the vehicle is running on a rough road , such as, an unpaved road or a bumpy road, data detected by the wheel revolution at speed sensors 74 and the speed sensor 19 are changeable because of the slip of the wheels. So, by comparing data detected by the wheel revolution at sensors 74 or by the vehicle speed sensor 19 and data detected by the second data detecting unit 97 or in the recording medium 105, it is possible to judge the accuracy of data detected by the second data detecting unit 97 or stored in the recording medium.

Detailed Description Text (45):
By comparing data about the width of a road lane or the number of the road lane detected by the laser cruise system 111 and data stored in the recording medium 105, it is possible to judge the accuracy of data stored in the recording medium 105.

Detailed Description Text (47):
Examples of control flows disclosed in FIG. 9 diagnose the accuracy of the route information detected by the second data detecting unit 97 by itself. First of all, at Step 21, the received signals to the GPS receiver 117 determines whether they are in failure. This determination is executed based on the number of man-made satellites which send radio waves received by the receiver, and the receiving condition of the radio waves.

Detailed Description Text (48):
If the answer of the Step 21 is NO, the flow goes to Step 22, the navigation system 70 decides whether the vehicle is running at the inappropriate place for receiving the radio waves, for example, in a tunnel or between high buildings. If the answer of the Step 22 is NO, the control flow goes to Step 23, and the flag, which in the ON state indicates the accuracy of data received by the GPS receiver is bad, is turned OFF and the control flow returns. At Step 21 or 22, the answer is YES, the control flow goes to Step 24, and the flag, which in the ON state indicates the accuracy of data received by the GPS receiver is bad, is turned ON and the control flow returns. Steps 21, 22, 23, and 24 correspond to the means for detecting accuracy of the detection of the information.

Detailed Description Text (49):
Example of control flows disclosed in FIG. 10 judge the possibility of the accuracy of the route information detected by the first data detecting unit 96 and the second data detecting unit 97 on the basis of data stored in the recording medium 105.

Detailed Description Text (50):
At Step 31, the same control is executed in Step 1 in FIG. 1. At Step 32 , it is decided whether there is a road which is parallel to the route within a predetermined distance by data stored in the recording medium 105. If the answer of the Step 32 is NO, the control flow goes to Step 33, because there exists only one route, so, even if the route is judged by the first data detecting unit 96 or the second data detecting unit 97, there is no possibility to incorrectly determine the current road.

Detailed Description Text (51):
At Step 33, it is decided whether there is more than two intersections within a predetermined distance of the specific intersection on the basis of data stored in the recording medium 105. If the answer of the Step 33 is NO, because there is only one intersection within a predetermined distance, when the first data detecting unit 96 or the second data detecting unit 97 recognize the intersection, it is not possible to incorrectly recognize the specific intersection as another intersection. So the flag, which indicates the accuracy of the detection of the first data detecting unit 96 or the second data detecting unit 97, is turned OFF. And the control flow returns. If the answer of the Step 32 is YES, it is a possible to incorrectly distinguish the road and not recognize on which road the vehicle is now, because there is another road that is parallel to the route within a predetermined distance according to data stored in the recording medium 105. So, the control flow goes to Step 35, the flag, which indicates the accuracy of the detection of the first data detecting unit 96 or the second data detecting unit 97, is turned ON. And the control flow returns.

Detailed Description Text (53):
Example of control flow disclosed in FIG. 11 judges the accuracy of the route information detected by the condition of the map matching. At Step 41, it is decided whether a time less than a predetermined time has elapsed or the vehicle has run less than a predetermined distance after the map matching. If the answer of Step 41 is YES, the flag, which indicates the accuracy of the detect of the route information, is turned OFF. The correction of the present location of the vehicle is finished by comparing data detected by the first data detecting units 96 and data stored in the recording unit 105. And the control flow returns. If the answer of Step 41 is NO, the control flow goes to Step 43, because it is possible not to finish correcting by comparing data, the flag, which indicates the accuracy of the detect of the route information, is turned ON. And the control flow returns. Steps 41, 42, and 43 correspond to the means for detecting accuracy of the detection of the information. At least one of the examples disclosed in FIG. 7 to FIG. 11 is executed, and the accuracy of the detection of the information detected by the navigation system is determined.

Detailed Description Text (54):
Examples of control flows disclosed in FIGS. 12 to 19 include, the changing controller, in other words, the means for changing the control patterns that are applied to control the behavior control system corresponding to the accuracy of the route information, for example, the flag which indicates the accuracy of the detection of the information is bad condition.

Detailed Description Text (55):
Disclosed in FIG. 12 is the control of the automatic transmission 2 by the transmission electronic control unit 55, which basically shifts down when the navigation system 70 detects a corner in front of the vehicle.

Detailed Description Text (56):
At Step 51, it is decided whether the flag, which indicates the accuracy of the detection of the information about a corner detected by the navigation system 70, is turned ON. If the answer of Step 51 is No, the control flow goes to Step 52, because the accuracy of detection of the route information by the navigation system 70 is better than predetermined degree, there is a corner, for example, an intersection where the vehicle will turn right or left. At Step 52 The automatic transmission 2 is automatically shifted down and the control flow returns.

Detailed Description Text (58):
If the answer of the Step 51 is YES, because there is no corner in front of the vehicle, the automatic transmission is not shifted down, and the control flow returns. Step 51 and 62 correspond to the means for detecting the accuracy of the detection of the information.

Detailed Description Text (60):
At Step 61, it is decided whether the flag, which indicates the accuracy of the detection of the information about the slope detected by the navigation system 70, is turned ON. If the answer of Step 61 is NO, the control flow goes to Step 62, because the accuracy of detection of the route information by the navigation system 70 is better than a predetermined degree, and there is a down slope in the road. At Step 62 The automatic transmission 2 is prohibited from controlling the shifting to a specific gear stage, in other words, shifting to the gear stage which has a smaller effect on the engine braking, or shifting up, and the control flow returns.

Detailed Description Text (61):
As result, the vehicle will run on the down slope in the road with a controlled speed and with sufficient engine braking. Thus the drivability is improved. And if the answer of Step 61 is YES, there is no down slope in the road, so the control flow returns. Steps 61 and 62 correspond to the changing controller, in other words, the means for which are applied to control the behavior control system corresponding to the accuracy of the route information.

Detailed Description Text (62):
Example of control flows disclosed in FIG. 14 is the other control example which changes the control pattern of the automatic transmission 2. Example of control flows

disclosed in FIG. 14 is the control of the automatic transmission 2 by transmission electronic control unit 55, which basically changes the shift pattern to the power pattern when the road requires an increase in the driving force, for example, a climbing road. They are detected by the navigation system 70.

Detailed Description Text (64):
At Step 71, it is decided whether the flag, which indicate the bad condition of the accuracy of the detection of the information about the climbing road by the navigation system 70, is turned ON. If the answer of Step 71 is NO, the control flow goes to Step 72, because the accuracy of detection of the route information by the navigation system 70 is better than a predetermined degree, and there is a climbing road. At Step 72, the control to change the shift pattern to the power pattern is executed, and the control flow returns. And if the answer of Step 71 is YES, there is no climbing road, so the control flow returns. Steps 71 and 72 correspond to the changing controller, in other words, the means which are applied to control the behavior control system correspond to the accuracy of the route information.

Detailed Description Text (65):
The other control examples which change the control pattern of the automatic transmission 2 are the following. For example, Step 51 of FIG. 12 is substituted with the following step. It is decided whether the vehicle has reached the end of the congestion. So if the vehicle reaches the end of the congestion, the automatic transmission 2 is shifted to a specific gear stage, in other words, shifting to the gear stage which has more of an effect on the engine braking, shifting down. And another example, Step 52 is substituted with the following step, if the vehicle goes through the curve, the shift is prohibited. And there are other examples, which changes the control patterns of the automatic transmission. One is when the vehicle is stopping in the congestion, then the automatic transmission control system executes the neutral control which is for decreasing fuel consumption. The other one is when the vehicle is running on the freeway or in the suburbs, the automatic transmission control system chooses the economy pattern of the shift diagram. Yet another one is when the vehicle is running on the climbing road or down slope road, the automatic transmission control system prohibits shifting up to the specific gear stage.

Detailed Description Text (66):
Example of control flows disclosed in FIG. 15 includes the changing controller, in other words, the means for changing the control patterns which are applied to the control of the brake system 65 corresponding to the accuracy of the route information detected by the navigation system 70. The control in FIG. 15 is basically when the down slope is detected in front of the vehicle by the navigation system 70, the oil pressure of the wheel cylinders 72 is increased corresponding to the degree of the slope as soon as possible.

Detailed Description Text (67):
At Step 81, it is decided whether the flag, which indicates the accuracy of the detection of the information about down slope road by the navigation system 70, is turned ON. If the answer of Step 81 is NO, the control flow goes to Step 82, because the accuracy of detection of the route information by the navigation system 70 is better than a predetermined degree, and there is a down slope in the road. At Step 82, the oil pressure of the wheel cylinders 72 of the brake system 65 is increased more than the oil pressure which corresponds to the amount of the brake pedal, and the control flow returns. As a result, the braking force of the brake system is controlled as an appropriate value for the degree of the slope. So the drivability is improved. And if the answer of Step 81 is YES, there is no down slope nor the degree of the slope is less than a threshold value, so the control flow returns. Steps 81 and 82 correspond to the changing controller, in other words, the means for changing the control patterns which are applied to control the behavior control system corresponding to the accuracy of the route information and the means for detecting accuracy of the detection of the information.

Detailed Description Text (68):
The example of control flow disclosed in FIG. 16 includes the changing controller, in other words, the means for changing the control patterns that are applied to the control of the vehicle auto drive control system 66 corresponding to the accuracy of the route information detected by the navigation system 70. The control in FIG. 16 is

basically when congestion is detected in front of the vehicle on the freeway by the navigation system 70, the control of the vehicle auto drive control is canceled. In FIG. 16, at Step 91, when the vehicle auto drive control system is set, it is decided whether the flag, which indicates the accuracy of the detection of the information about the congestion on the road by the navigation system 70, is turned ON. If the answer of Step 91 is NO, the control flow goes to Step 92, because the accuracy of detection of the route information by the navigation system 70 is better than a predetermined degree, and there is congestion in front of the vehicle. At Step 92, the vehicle auto drive control is canceled, and the control flow returns. And if the answer of Step 91 is YES, the vehicle auto drive control is continued. Steps 91 and 92 correspond to the changing controller, in other words, the means for changing the control patterns that are applied to control the behavior control system corresponding to the accuracy of the route information.

Detailed Description Text (69):
The example of control flows disclosed in FIG. 17 includes the changing controller, in other words, the means for changing the control patterns that are applied to control the suspension system 67 corresponding to the accuracy of the route information detected by the navigation system 70. The control in FIG. 17 is basically when unpaved road or rough road is detected in front of the vehicle by the navigation system 70, the damping force of the shock absorbers 79 or air springs 80 is increased, in other words, the suspension system is made hard.

Detailed Description Text (70):
In FIG. 17, at Step 101, when the vehicle auto drive control system is set, it is decided whether the flag, which indicates the accuracy of the detection of the information about a surface of a road by the navigation system 70, is turned ON. If the answer of Step 101 is NO, the control flow goes to Step 102, because the accuracy of detection of the route information by the navigation system 70 is better than a predetermined degree, and there is unpaved or rough road in front of the vehicle. At Step 102, the control increases the damping force of the suspension system 67, and returns. As a result, the vibration of the vehicle is controlled when the vehicle is on unpaved or rough road, and the comfort of the vehicle is improved. If the answer of Step 101 is YES, the control flow returns and the damping force value of the suspension system is kept the same as before. Steps 101 and 102 correspond to the changing controller, in other words, the means for changing the control patterns that are applied to control the behavior control system corresponding to the accuracy of the route information.

Detailed Description Text (71):
The example of control flows disclosed in FIG. 18 includes the changing controller, in other words, the means for changing the control patterns that are applied to the control of the steering system 68 corresponding to the accuracy of the route information detected by the navigation system 70. The control in FIG. 18 is basically when unpaved or rough road is detected in front of the vehicle by the navigation system 70, the oil pressure of the gear box 85 of the steering system 68 is increased.

Detailed Description Text (72):
In FIG. 18, at Step 111, it is decided whether the flag, which indicates the accuracy of the detection of the information about congestion on the road by the navigation system 70, is turned ON. If the answer of Step 111 is NO, the control flow goes to Step 112, because the accuracy of detection of the route information by the navigation system 70 is better than a predetermined degree, and there is unpaved or rough road in front of the vehicle. At Step 112, the control increases the oil pressure of the gear box 85 of the steering system 68, and the control flow returns. As a result, by only giving a small force to the steering wheel 83, the stability of the operating direction is achieved. The stability, the controllability and the drivability are thus improved.

Detailed Description Text (73):
If the answer of Step 111 is YES, the control flow returns because the route is comparatively smooth. Steps 111 and 112 correspond to the changing controller, in other words, means for changing the control patterns that are applied to control the behavior control system corresponding to the accuracy of the route information.

Detailed Description Text (74):
The example of control flows disclosed in FIG. 19 includes the changing controller, in other words, the means for changing the control patterns that are applied to the control of the engine power corresponding to the accuracy of the route information detected by the navigation system 70. The control in FIG. 19 is basically when congestion is detected in front of the vehicle by the navigation system 70, the fuel injection control system decreases the amount of the fuel injection.

Detailed Description Text (75):
In FIG. 19, at Step 121, it is decided whether the flag, which indicates the accuracy of the detection of the information about congestion on the road by the navigation system 70, is turned ON. If the answer of Step 121 is NO, the control flow goes to Step 122, because the accuracy of detection of the route information by the navigation system 70 is better than predetermined degree, and the vehicle is in congestion. At Step 122, the electronic throttle valve is shut irrespective of the amount of the acceleration pedal operation, and the amount of the fuel supply is decreased, and the control flow returns. As a result, overheating of the catalyst is prevented and the saving of the fuel is executed.

Detailed Description Text (76):
If the answer of Step 121 is YES, the control flow returns because there is no possibility for the vehicle to enter congestion. Steps 121 and 122 correspond to the changing controller, in other words, the means for changing the control patterns that are applied to the control of the behavior control system corresponding to the accuracy of the route information and to the means for detecting accuracy of the detection of the information.

Detailed Description Text (78):
As above disclosed, the control device for a vehicle, which controls behavior of the vehicle based on the information regarding the route which the vehicle will follow, judges the accuracy of the route information by the accuracy detect means mentioned in FIG. 7 to FIG. 11, and the control patterns are changed, by the means for the control patterns mentioned in FIG. 12 to FIG. 19, corresponding to the accuracy of the route information.

Detailed Description Text (79):
So when the accuracy of the detection of the information about the route detected by the navigation system 70 is bad, which does not reflect the actual conditions, the behavior control of the vehicle, which corresponds to the incorrectly detected information, is not executed. As a result it is possible to adapt the behavior control for the vehicle to the actual road condition appropriately. And the capability of the power train, the stability and controllability, drivability are thereby improved.

Detailed Description Text (80):
In this invention, the changing controller, in other words, the means for changing the control patterns that are applied to control the behavior control system corresponding to the accuracy of the route information, includes the function which prohibits the application of the control patterns corresponding to the road condition, includes the function which changes the degree of the control corresponding to the degree of the accuracy of the road condition, and changes one control pattern to the other control pattern.

Detailed Description Text (81):
In the control that has the function of changing the degree of the control corresponding to the degree of the accuracy of the road condition, the accuracy of the detection of the information is classified and the multiple standards are predetermined corresponding to the multiple classifications of the information, and the different control which has different contents are executed. For example, the shift control of the automatic transmission has several threshold values which are used to determine when to shift, and these values correspond to the degree of the accuracy of the detection of the information. In this invention, the changing controller, in other words, the means for changing the control patterns that are applied to the control of the behavior control system, includes the function which corrects the standard control pattern by calculation and uses multiple control

patterns that are predetermined. In this invention, it is possible to use the electronic motor as a drive force resource, to use continuously variable transmission (CVT) as a automatic transmission, and to use the manual transmission in stead of the automatic transmission.

Detailed Description Text (82):
In this specification, the behavior control system includes the engine 1, the automatic transmission 2, the servo motors 4, the electronic throttle valve 5, the fuel injection control system 6, the ignition timing adjusting unit 7, the hydraulic control device 54, the brake system 65, the vehicle auto drive control system 66, the suspension system 67, and the steering system 68. The route information detector includes the navigation system 70. The control system for the vehicle can control at least one of the behavior control systems on the basis of the route information by the navigation system. The control pattern of the behavior control system includes the following patterns.

Detailed Description Text (83):
When the vehicle goes through a curvy and winding road, the automatic transmission 2 is shifted down to reduce the vehicle speed by using the engine brake. When the vehicle starts on the road which has low frictional coefficient, the automatic transmission is set at the second gear stage in order to control the slip of the wheels. It is possible to prohibit a shifting down to smaller than the specific gear stages in order to control the slip of the wheels when the vehicle runs on a road which has a low frictional coefficient. It is possible to prohibit from shifting when the vehicle runs on a curve. It is possible to shift down when the vehicle reaches the end of a congestion, the automatic transmission 2 is shifted to a specific gear stage, in other words, shifting to the gear stage which has a larger effect on the engine braking, i.e., shifting down.

Detailed Description Text (84):
At the brake system 65, when the vehicle runs on the road which has low frictional coefficient, it is possible to control the oil pressure of the wheel cylinders 72 in order to prevent the wheels from slipping during braking. When the vehicle runs on a slope down, it is possible to control the oil pressure of the wheel cylinders 72 in order to increase the braking force.

Detailed Description Text (86):
At the suspension system 67, when a vehicle runs on an unpaved road, it is possible to increase the damping force of the shock absorbers 79 or the air springs 80 in order to control the vibration of the vehicle. When a vehicle runs at the transition from a straight road to a curve, it is possible to increase the damping force of the rear wheels. When the vehicle is rounding a corner, it is possible to increase the damping force in order to achieve an under steering condition. These controls improve the stability and controllability, drivability, and comfort.

Detailed Description Text (87):
At the steering system 68, when the vehicle runs on an unpaved road or a rough road, it is possible to increase the oil pressure to the gear box 85 in order to decrease the operating force of the steering wheel 83 and to improve the stability of the direction.

Detailed Description Text (89):
There is a condition which the route information is different from the actual driving condition. In other words, there is a possibility that the accuracy of the detection of the information becomes bad, a failure occurs, and the error is made. The reasons of these phenomena are following, it is impossible to receive the radio waves because the radio wave are blocked by obstacles, each element of the first data detecting unit 96 has errors, or the various sensors have errors because of slips of the wheels and so on.

Detailed Description Text (90):
If conditions of the route information are different from the actual driving conditions, which happens when the vehicle runs on a Y shape road, when the vehicle runs on a hairpin curve, when the vehicle runs between high buildings, when the vehicle is on a turntable, when the vehicle runs in a tunnel, when the vehicle runs

under an elevated track, when the vehicle uses non-standardized tires, when the vehicle runs on a road which does not exist on a map, and the vehicle is carried by a ferry. And furthermore, various kinds of the road constructions, the expansion of reclaimed land, and a tunnel which is newly opened causes a difference between the actual road condition and the map data stored in the recording medium 105. So when the accuracy of the route information is low, the behavior control system is controlled by the control patterns on the basis of the route information, and the correspondence of the road condition and the vehicle behavior will be lacking. As a result, the stability and controllability, drivability, and comfort are bad. So this invention has a control pattern changing means for changing the control pattern corresponding to the accuracy of the route information of the navigation system 70.

Detailed Description Text (93):
In FIG. 20, the navigation system 70 or the transmission control unit 55 detects not only an immediate vehicle speed decreasing point, at which it is necessary to decrease the speed of the vehicle, but also the vehicle speed decreasing point within the predetermined distance place. And it determines whether the decrease in the speed needs to be more than the threshold or not at each place. And this determination is used for the control of the automatic transmission 2. First of all, the driver's operation for the setting of the destination and the indication of the map of the operating route is executed by using the switches 107 of the multiple audio visual system 99. The present position of the vehicle and the road ahead of the present position can be specified by data of the first data detecting unit 96 and the second data detecting unit 97.

Detailed Description Text (102):
If the answer of the Step 308 is YES, it means that the all of the calculations about the vehicle target speed Vt, corresponding to the all the corners N, which are detected in Step 301, are finished. At Step 309, it is decided whether the target corner It is more than 0. If It is more than 0, it means that there is more than one corner where vehicle is not able to decrease its speed to the vehicle target speed Vt at the rate less than the target deceleration. And it is decided whether the distance from the present position to the immediate corner is less than the threshold value. And it is decided whether the present vehicle speed V is more than the vehicle target speed Vt, in other words, the present vehicle speed V is more than the minimum value of the required vehicle speed Vi. And it is decided whether the vehicle is on the straight road.

Detailed Description Text (103):
At Step 309, if the all criteria are satisfied, the control flow goes to Step 310. In other words, if there exists more than one target corner It and the corner is located on a straight road within the threshold distance from the present position, the control flow goes to Step 310. Because there exists It, there is little possibility to accelerate before entering the target corner, and the reduction of the vehicle speed or the shift down has little influence on the vehicle, stability of the vehicle, and the drivability.

Detailed Description Text (106):
According to the control flow shown in FIG. 20, when the corner is detected on the road ahead of the present position by the navigation system, the gear stage is only shifted down if the deceleration from the present vehicle speed to the required vehicle speed Vi is more than the threshold value. The shift down of the gear stage is used to get the engine to brake easily. So it is possible that when the criteria are satisfied, the control will be executed to get the engine brake effect.

Detailed Description Text (108):
A control flow shown in FIG. 21, which is one of the examples, describes the embodiment in the Step 301 of the flow in FIG. 20. FIG. 21 shows the control flow which detects the corners on the road ahead of the present position during the present vehicle speed decrease to zero by the target deceleration, which corresponds to the present speed.

Detailed Description Text (111):
The target speed decreasing rate Gt (N) is calculated by using formula 1. mGt is a one of data from the map which stores the mGt corresponding to the vehicle speed VN. mGt

is corrected by the road slope which is stored in the recording medium 105. M is the number of data points of the slope degree. VN is renewed by using formula 2. If the vehicle runs at VN at the beginning and it runs Li distance, VN is renewed as the ending speed by decreasing the vehicle speed at the target deceleration. If the result of the (VN*VN-2*Gt (N*)Li) is less than 0, VN=0 is set. On a straight road to the next corner, it is possible to determine the slope data by using the actual information of the vehicle, not using data from the data recording medium. In detail, it is calculated by comparing a standard acceleration value which is stored in the engine electronic control unit (E-ECU) 10 and the actual acceleration value which is calculated from information from the vehicle speed sensor 19.

Detailed Description Text (114):
If the answer of Step 323 is NO, the control flow goes to Step 328. Detection for all of the corners, which exist between the present position and where the vehicle stops, are finished. At Step 328, if a diverging point, such as an intersection, is detected between the present point and the distance of Lf by the navigation system 70, it is impossible to predict which way the driver will choose. So control of the detecting the corners stopped and the control flow returns. The loop is constructed by Steps 321, 323, and 327, and the loop counter is i.

Detailed Description Text (115):
The control flow shown in FIG. 22, which is another example, describes the embodiment of Step 301 of the flow in FIG. 20. FIG. 22 shows the control flow which detects the corners on the road ahead of the present position during the present vehicle speed decrease to zero by a predetermined deceleration from the present vehicle speed.

Detailed Description Text (118):
As a standard value is determined by the map which stores the target deceleration corresponding to the present vehicle speed mGt. mGt is corrected by the road slope which is stored in the recording medium 105 and the target deceleration Gt is determined. This calculation is executed by a formula 3. ##EQU2##

Detailed Description Text (126):
FIG. 23 shows the detail procedure for calculating the required vehicle speed Vi. At Step 341, it is decided whether the vehicle is still running the same straight road or the corner where the required vehicle speed was calculated last time. And it is decided whether there is no change in the slope degree or the radius of the corner.

Detailed Description Text (128):
The navigation system 70 detects the distance of the straight road before the corner of j turn. And a predicted running time t is calculated during running on the straight road. The predicted running time t indicates the time which is needed for the vehicle speed to be the required vehicle speed Vi by decreasing the speed at the predetermined deceleration on a straight road. The predictive running time is calculated by using formula 4.

Detailed Description Text (129):
At formula 4, Gt (j) indicates the deceleration. L1 indicates the distance of the straight road. At Step 343, the required vehicle speed Vi which is for the straight road before the corner in j turn is calculated by using the following formula.

Detailed Description Text (130):
Vi in the right side of the formula indicates the present vehicle speed. If the vehicle speed is reduced after the vehicle enters the corner, there is possibility that the behavior of the vehicle will be inappropriate and the stability of the vehicle will decline. So the control of Step 343 is executed, in detail, when the vehicle runs on the straight road, before entering the corner j, and the vehicle speed is reduced and when the vehicle enters the corner, the speed of the vehicle is kept almost the same during the rounding the corner.

Detailed Description Text (135):
It is possible for automatic transmission 2 to control other systems to decrease the vehicle speed. In such a case, the information about the corner detected by the navigation system 70, the distance between present position and the corner, and the radius of the corner are used for the control.

Detailed Description Text (136):
For example, if the vehicle speed decreasing point is detected by the navigation system 70, electronic throttle valve 5 is shut to increase the force of engine braking, the oil pressure for the wheel cylinders 72 of the brake system 65 is controlled to increase the force of the braking, and the control of the same speed control, by the vehicle auto drive control system 66, is canceled to decrease the speed.

Detailed Description Text (137):
The predetermined target side direction acceleration is corrected by the coefficient of friction of the road which is determined based on the revolving speed difference by wheel speed 71 and the braking force is controlled.

Detailed Description Text (141):
The following example is also possible. The road slope is detected based on data from the vehicle speed sensor 19, throttle sensor 18, engine revolving speed sensor 15, and the slope sensor 109. The vehicle speed when the vehicle enters the corner is predicted on the basis of the detected data. And if the predicted speed is higher than a permissible speed, the automatic transmission 2 shifts down.

Detailed Description Text (144):
Furthermore, the automatic transmission 2 is controlled on the basis of the road conditions detected by the navigation system 70, if a diverging point, such as an intersection, is detected on the road ahead of the present position, it is impossible to predict which way the driver will choose. So control of the detecting the corners is stopped or control of the automatic transmission 2 is prohibited. As a result, it is possible to prevent disagreement between the road condition and the driving force of the vehicle, and improve the drivability. This invention is applicable to the automatic transmission which is capable of setting three forward gear stages or four forward gear stages. And this invention is applicable to the vehicle which is equipped an electronic motor as a power source. In this invention, it is possible not to down shift if the deceleration is smaller than the threshold value. And this invention reduces the number of the transmission condition changes, for example, down shift, as possible as it can. So it is able to control the shift shock of the automatic transmission and improve the comfort of the vehicle and drivability. The invention prohibits a down shift during the corner, so it is improves the shift shock and the behavior of the vehicle and stability of the vehicle.

Detailed Description Text (145):
In this invention, transmission is defined as automatic transmission and the operating route information detector is defined as the navigation system. The vehicle speed decreasing point includes anywhere that is detectable by the navigation system and it is necessary to decrease the vehicle speed, for example, a stop place which is determined by traffic regulation, a obstacle including fallen trees and fallen stones, down slope road, low frictional coefficient road, the end of congestion, and so on.

CLAIMS:

1. A control system for a vehicle, which has a route information detector which detects route information, and a behavior control system, which is controlled by the route information detected by the route information detector and controls the behavior of the vehicle, said control system comprising:

a means for detecting the accuracy of the detection of the route information; and

a changing controller which changes the control of the behavior control system based on the accuracy of the detection of the route information;

wherein the behavior control system includes a transmission of a vehicle.

2. A control system for a vehicle, which has a route information detector which detects route information, and a behavior control system, which is controlled by the route information detected by the route information detector and controls the behavior of the vehicle, said control system comprising:

a means for detecting the accuracy of the detection of the route information; and

a changing controller which changes the control of the behavior control system based on the accuracy of the detection of the route information;

wherein the behavior control system includes a brake system of a vehicle.

3. A control system for a vehicle, which has a route information detector which detects route information, and a behavior control system, which is controlled by the route information detected by the route information detector and controls the behavior of the vehicle, said control system comprising:

a means for detecting the accuracy of the detection of the route information; and

a changing controller which changes the control of the behavior control system based on the accuracy of the detection of the route information;

wherein the behavior control system includes an engine system of a vehicle.

4. A control system for a vehicle, which has a route information detector which detects route information, and a behavior control system, which is controlled by the route information detected by the route information detector and controls the behavior of the vehicle, said control system comprising:

a means for detecting the accuracy of the detection of the route information; and

a changing controller which changes the control of the behavior control system based on the accuracy of the detection of the route information;

wherein the behavior control system includes a vehicle auto drive control system.

5. A control system for a vehicle, which has a route information detector which detects route information, and a behavior control system, which is controlled by the route information detected by the route information detector and controls the behavior of the vehicle, said control system comprising:

a means for detecting the accuracy of the detection of the route information:

a changing controller which changes the control of the behavior control system based on the accuracy of the detection of the route information;

a control system for a transmission, which is controlled by a shift instruction based on a predetermined shift diagram; and a route information detector which detects information on a route that the vehicle follows;

a vehicle speed decreasing point detector which detects a point where it is necessary to decrease the vehicle speed; and a vehicle target speed calculator which calculates a vehicle target speed for the vehicle speed decreasing point;

a target deceleration calculator which calculates a decrease speed to the vehicle target speed;

a vehicle deceleration calculator which calculates a deceleration to make a present vehicle speed be the target speed; and

a deceleration judgment device which decides whether said deceleration is larger than a threshold value; and a transmission condition change device which changes a transmission condition to effect an engine braking condition when the deceleration judgment device decides that the deceleration is larger than the threshold value.

7. A method for controlling a vehicle, comprising the steps of:

controlling a behavior control system of the vehicle based on the information detected by a route information detector, and controlling the behavior of the vehicle;

detecting the accuracy of the detection of the route information; and

changing the control of the behavior control system based on the accuracy of the detection of the route information.

8. The method for controlling a vehicle according to claim 7, further comprising the step of:

changing control patterns based on the control patterns which correspond to the route information.

9. The method for controlling a vehicle according to claim 7, further comprising the steps of:

controlling a transmission, which controls the transmission by a shift instruction based on a predetermined shift diagram and route information which is on a route that a vehicle follows; and

detecting a point where it is necessary to decrease the vehicle speed; and

calculating a vehicle target speed for the vehicle speed decreasing point; and

calculating a decrease speed to the vehicle target speed; and

a vehicle deceleration calculating a deceleration to make the present vehicle speed be the target speed; and

determining whether said deceleration is larger than a threshold value; and

changing the transmission condition effects an engine braking condition when the deceleration is larger than the threshold value.

11. A control system for a vehicle, which has a route information detector which detects the location of the vehicle, and a behavior control system, which is controlled by the location detected by the route information detector, controls the behavior of the vehicle, said control system comprising:

means for calculating the location of the vehicle;

means for determining the accuracy of the calculated location of the vehicle by comparing the calculated location with position data, wherein said position data includes areas that are not driveable by said vehicle; and

a controller which controls the behavior control system based on the accuracy of the calculated location of the vehicle.

12. A control system for a vehicle, which has a route information detector which detects the location of the vehicle, and a behavior control system, which is controlled by the location detected by the route information detector, controls the behavior of the vehicle, said control system comprising:

means for calculating the location of the vehicle;

means for detecting a curve driving condition of the vehicle;

means for supplying stored curve condition data based on the calculated location of the vehicle;

means for determining the accuracy of the calculated location of the vehicle by comparing the curve driving condition with the supplied stored curve condition data; and

a controller which controls the behavior control system based on the accuracy of the calculated location of the vehicle.

13. A control system for a vehicle, which has a route information detector which detects the location of the vehicle, and a behavior control system, which is controlled by the location detected by the route information detector, controls the behavior of the vehicle, said control system comprising:

means for calculating the location of the vehicle;

a sensor for determining a slip condition of the vehicle and the road;

means for supplying slip condition data based on the calculated location of the vehicle;

means for determining the accuracy of the calculated location of the vehicle by comparing the determined slip condition with said supplied slip condition data; and

a controller which controls the behavior control system based on the accuracy of the calculated location of the vehicle.

14. A control system for a vehicle, which has a route information detector which detects the location of the vehicle, and a behavior control system, which is controlled by the location detected by the route information detector, controls the behavior of the vehicle, said control system comprising:

means for calculating the location of the vehicle;

a sensor for determining a lane condition of the road;

means for supplying lane information data based on the calculated location of the vehicle;

means for determining the accuracy of the calculated location of the vehicle by comparing the lane condition with said supplied lane information data; and

a controller which controls the behavior control system based on the accuracy of the calculated location of the vehicle.

15. A control system for a vehicle, which has a route information detector which detects the location of the vehicle, and a behavior control system, which is controlled by the location detected by the route information detector, controls the behavior of the vehicle, said control system comprising:

means for calculating the location of the vehicle;

means for supplying position data;

means for determining the accuracy of the calculated location of the vehicle by comparing the calculated location of the vehicle and position data wherein the position data includes areas a GPS is inoperable; and

a controller which controls the behavior control system based on the accuracy of the calculated location of the vehicle.

16. A control system for a vehicle, which has a route information detector which detects the location of the vehicle, and a behavior control system, which is controlled by the location detected by the route information detector, controls the behavior of the vehicle, said control system comprising:

means for calculating the location of the vehicle;

means for supplying road data;

means for determining the accuracy of the calculated location of the vehicle by comparing the calculated location of the vehicle with road data, wherein said road data includes a location parallel to said calculated location of said vehicle; and

a controller which controls the behavior control system based on the accuracy of the calculated location of the vehicle.

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TITLE: Apparatus for watching around vehicle

Brief Summary Text (15):
Further, information on spots with poor visibility is included in car navigation maps to allow an apparatus for watching around a vehicle to decide whether the display of images around a vehicle will be needed on the basis of positional information indicating the present position of the vehicle by means of the information on spots with poor visibility, GPS and the like, whereby switching the on and off states of image display can be conducted automatically (second prior art).

Brief Summary Text (30):
Preferably, the apparatus for watching around a vehicle is such that the distance measuring unit detects the distance between the vehicle and each of the obstacles positioned on both the left and right sides of the vehicle during the travel of the vehicle; and the controller detects a space between the left- and right-hand obstacles on the basis of the distance between the vehicle and each of the left- and right-hand obstacles detected by the distance measuring unit, regards the space as width of a road on which the vehicle is traveling, decides whether or not the display of the image on the display unit will be needed on the basis of the value of the width thereof, and controls the display unit over switching the on and off states of display according to the decision made thereby.

Brief Summary Text (31):
Preferably, the apparatus for watching around a vehicle further comprises a travel-condition detector for accepting at least one vehicle signal for making reduced vehicle speed detectable out of vehicle signals indicating travel conditions which are output from a plurality of vehicle portions, and detecting the reduced vehicle speed according to the one vehicle signal, wherein the controller decides whether or not the display of the image on the display unit will be needed on the basis of the width of the road detected by the distance measuring unit and the result detected by the travel-condition detector, and controls the display unit over switching the on and off states of display according to the decision made thereby.

Brief Summary Text (32):
Preferably, the apparatus for watching around a vehicle further comprises a travel-condition detector for detecting vehicle speed by accepting a vehicle signal indicating vehicle speed, wherein the controller decides that the display of the image by the display unit will be needed only in case where the width of the road detected by the distance measuring unit is equal to a predetermined reference distance or less and where the vehicle speed detected by the travel-condition detector is a predetermined reference speed or lower, and causes the image to be displayed on the display unit.

Brief Summary Text (33):
Preferably, the apparatus for watching around a vehicle is such that the image pick-up unit is installed in the front end portion of the vehicle and used to pick up images in left and right directions in front of the vehicle.

Drawing Description Text (4):
FIG. 3 is an overall block diagram descriptive of an apparatus for watching around a vehicle according to a second embodiment of the invention.

Drawing Description Text (10):
FIG. 9 is a diagram showing the travel-condition of a vehicle on a road with the apparatus for watching around a vehicle of FIG. 8.

Drawing Description Text (11):
FIG. 10 is a diagram showing the travel-condition of a vehicle on a road with the apparatus for watching around a vehicle of FIG. 8.

Detailed Description Text (33):
A description will be given of the operation of the switch control portion 117 when the vehicle speed is reduced as it is coming near to the intersection with reference to a flowchart of FIG. 5.

Detailed Description Text (35):
The vehicle speed is reduced further and when vehicle speed V reaches the upper threshold speed Va or lower, Step S3 is followed and an ON control signal is applied from the switch control portion 117 to each of the camera power switch 114 and the display unit power switch 116. The camera power switch 114 and the display unit power switch 116 are controlled so that both may be turned on in synchronization with each other. At this time the video signals witch 115 are held OFF. Consequently, the video signals of the left and right images picked up by the CCD camera 111 are not applied to the display unit 104 at this time, whereupon no images are displayed on the display unit 104.

Detailed Description Text (38):
The operation of the switch control portion 117 will be described with reference to a flowchart of FIG. 6 in case where a normal travel condition is restored by acceleration after the vehicle in the reduced speed condition passes through the intersection zone.

Detailed Description Text (41):
As described above, according to this embodiment of the invention, the vehicle speed is reduced from the normal travel condition to the upper threshold speed Va or lower, the power is supplied to turn on the CCD camera 111 and the display unit 104. After the passage of the predetermined time until the operation of the CCD camera 111 as well as the display unit 104 is stabilized, the video signal switch 115 is then turned on in this system. A noise image disturbance at the initial stage of the rise of the CCD camera 111 is effectively prevented from being displayed and display quality is made improvable.

Detailed Description Text (50):
FIG. 8 is a block diagram showing the configuration of an apparatus for watching around a vehicle according to a fourth embodiment of the present invention. FIGS. 9 and 10 are diagrams each showing the travel-condition of a vehicle on a road with the apparatus for watching around a vehicle of FIG. 8.

Detailed Description Text (52):
As shown in FIG. 10, the camera 201 is installed in the front end portion of the vehicle and used to pick up images in image pick-up areas (dead angle areas) 213 and 215 on the left and right sides in front of the vehicle. The display 203 is installed in a position visible to a driver in the vehicle and used to display the image picked up by the camera 201 or a car navigation image in case where the vehicle is equipped with a car navigation unit. The power switch 209 is a switch for turning on and off the apparatus for watching around a vehicle.

Detailed Description Text (53):
As shown in FIG. 9, the distance measuring sensor 205 is installed on both the left and right sides of the front end portion of the vehicle and used to detect not only the presence or absence of obstacles on both the left and right sides of a road 221 during the travel of the vehicle but also distances up to the respective obstacles 223 and 225 by means of a distance measuring signal (ultrasonic wave in this case) 217 under the control of the control unit 211. The distance measuring sensors 205 also supplies the detected results to the control unit 211.

Detailed Description Text (54):
More specifically, according to the fourth embodiment of the invention, the ultrasonic wave is used as a distance measuring signal 217. Each of the left and right distance measuring sensors 205 periodically transmits the ultrasonic wave 217 in the lateral directions of the vehicle and receives the reflected wave. Moreover, each of the left and right distance measuring sensors 205 also detects the presence or absence of the reflected wave and the passage of time from the transmission of the ultrasonic wave 217 up to the reception thereof, so that it detects not only the presence or absence of the obstacles 223 and 225 on the left and right sides of the road 221 during the travel of the vehicle but also the distances up to the respective obstacles 223 and 225. In this case, the obstacles 223 and 225 as objects for detection include those which are so erected as to obstruct the view of the driver such as buildings, walls and the like.

Detailed Description Text (57):
The control unit 211 decides whether or not the display of the image picked up by the camera 201 will be needed on the basis of the results detected by the distance measuring sensors 205 and the travel-condition detecting portion 207. The control unit 211 also functions as what causes the image picked up by the camera 201 to be displayed on the display 203 according to the decided results. Further, the control unit 211 causes any other image such as a navigation image or the like to be displayed on the display 203 as occasion demands unless the image picked up by the camera 201 is displayed on the display 203.

Detailed Description Text (58):
More specifically, in case where the control unit 211 detects via the distance measuring sensors 205 the presence of the obstacle 223 and 225 so positioned as to obstruct the view of the driver on both the left and right sides of the road 221 during the travel of the vehicle, it also detects the space between the obstacles 223 and 225 on both the left and right sides on the basis of the distance between the vehicle and each of the left and right obstacles 223 and 225 detected by the distance measuring sensor 205, the space being regarded as the width of a road during the travel of the vehicle. Only in case where the width of the road is equal to a predetermined reference distance or less and where the vehicle speed detected by the travel-condition detecting portion 207 is a predetermined reference speed (e.g., 10 km/h) or lower, the control unit 211 decides that the display of the image picked up by the camera 201 will be needed and turns on the display 203 so that the image picked up by the camera 201 may be displayed thereon.

Detailed Description Text (59):
FIG. 11 is a flowchart (subroutine) showing the principal control contents of the control unit 211. At Step S1, a degree of unobstructed view on the left and right sides of the road 221 during the travel of the vehicle is detected via the distance measuring sensor 205 and then Step S2 is followed. At Step S1, the presence or absence of obstacles 223 and 225 so positioned as to obstruct the view of the driver on the left and right sides of the road 221 during the travel of the vehicle as well as the width of the road during the travel of the vehicle is detected via the distance measuring sensors 205.

Detailed Description Text (60):
At Step S2, it is decided whether a lateral vista of the road 221 is good or bad on the basis of the detected results at Step S1. In case where the results are bad, Step S3 is followed, whereas the results are not bad, the display of the image picked up by the camera 201 is decided to be unnecessary and Step S5 is followed.

Detailed Description Text (61):
More specifically, the obstacles 223 and 225 so positioned as to obstruct the view of the driver on the left and right sides of the road 221 during the travel of the vehicle exist at Step S3. In case where the space between the obstacles 223 and 225 (width of the road 221) has the predetermined reference distance or less, the field of vision is decided to be bad. In any other case (e.g., the obstacles 223 and 225 are non-existent or even existent, the width of the road 221 has the predetermined reference distance or greater) the field of vision is decided to be good.

Detailed Description Text (63):

The reason for deciding whether or not the vehicle speed will be the reference speed or lower at Step S3 is as follows. Even in case where the road 221 offers poor visibility on the left and right sides during the travel of the vehicle, the vehicle speed is often set at the value of the reference speed or greater with respect the road 221 free from branching points such as crossroads and the like, and free from fear of colliding with any other vehicle coming from the left or right side thereof (i.e., the display of the image picked up by the camera 201 is unnecessary). On the contrary, in case where the road 221 is a narrow one offering poor visibility on the left and right side, and not free from fear of colliding with any vehicle coming from the left or right side thereof (i.e., the display of the image picked up by the camera 201 is necessary), the vehicle speed is often set at the reference speed or lower since the driver will have to drive the vehicle while watching around the left and right sides of the road 221.

Detailed Description Text (64):
Consequently, according to the fourth embodiment of the invention, attention is riveted to the point above in order to prevent the image picked up by the camera 201 from being unnecessarily displayed, whereupon it has been so arranged as to decide whether or not the display of the picked-up image will be needed by taking into consideration the travel condition of the vehicle (vehicle speed in this case).

Detailed Description Text (65):
At Step S4, the image picked up by the camera 201 is displayed on the display 203 and the next processing is performed. At Step S4, the image displayed on the display 203 is switched to the image picked up by the camera 203 in case where any other image such as a car navigation image or the like has been displayed on the display 203 at that point of time.

Detailed Description Text (66):
Therefore, as shownin FIG. 10, while the vehicle is traveling on the road 221 offering poor visibility on the left and right sides of the vehicle and it is coming near a T-shaped road offering poor visibility on the left and right sides of the vehicle, when the driver lowers the vehicle speed up to the reference speed or lower in an attempt to confirm the left and right directions of the T-shaped road, the contents of display on the display 203 are automatically switched. As shown in FIG. 10, an image resulting from picking up an area ranging from 213 to 215 in the lateral direction of the T-shaped road is to be displayed on the display 203.

Detailed Description Text (69):
As set forth above, according to the fourth embodiment of the invention, the display of images around the vehicle on the display 203 is decided to be necessary only when the width of the road 221 during the travel of the vehicle has the predetermined reference distance or less and only when the vehicle speed is the reference speed or lower, and the images around the vehicle are displayed on the display 203. Accordingly, only in case where the width of the road 221 is narrow and where the driver lowers the vehicle speed in order to watch around the vehicle, the images around the vehicle are allowed to be displayed on the display 203. Thus, the display of images around the vehicle can be made automatically and precisely with a low-cost construction in proportion to a visual field over the surroundings of a road and the travel conditions of the vehicle. As a result, images around the vehicle are prevented from being displayed in any useless place, which also prevents the interruption of driving.

Detailed Description Text (70):
As the camera 201 is installed in the front end portion of the vehicle and adapted to pick up the images in left and right directions in front of the vehicle, the left and right sides can precisely be confirmed at cross-shaped and T-shaped intersections by reference to the images picked up by the camera 201.

Detailed Description Text (72):
In this case, the control unit 211 is set to decide that the display of the image picked up by the camera 201 on the display 203 will be needed and to turn on the display 203 so as to display the image picked up by the camera 201 only in case where the width of the road 21 detected via the distance measuring sensor 205 is equal to the predetermined reference distance or less; the actuation of the brake is detected

by the travel-condition detecting portion 207; and the vehicle speed detected by the travel-condition detecting portion 207 is the predetermined reference speed (e.g., 10 km/h) or lower.

Detailed Description Text (82):
According to the invention, the apparatus for watching around a vehicle is provided with the distance measuring unit for detecting the distance between the vehicle and the obstacle so positioned as to obstruct the view of the driver on at least one side out of both sides of the vehicle during the travel of the vehicle, and the controller for deciding whether or not the display of the image on the display unit will be needed on the basis of the distance detected by the distance measuring unit and controlling the display unit over switching the on and off states of display according to the decision made thereby. Thus, the display of images around the vehicle can be made automatically and precisely with a low-cost construction in proportion to a visual field over the surroundings of a road and the travel conditions of the vehicle. As a result, images around the vehicle are prevented from being displayed in any useless place, which also prevents the interruption of driving.

Detailed Description Text (83):
According to the invention, switching the on and off states of the display of images around the vehicle can be conducted precisely in proportion to the width of a road in the urban area where buildings and the like are erected close to both sides of the road.

Detailed Description Text (84):
Since how much the driver feels the necessity of visibility around the vehicle is typically represented by the vehicle speed and the variation of the vehicle ~~speed,~~ (i.e., speed is reduced when visibility of the surroundings is needed), the controller is made to decide whether or not the display of the image on the display unit will be needed on the basis of the width of the road detected by the distance measuring unit and the result detected by the travel-condition detector, and able to control the display unit over switching the on and off states of display by taking into consideration the visibility around the road and the necessity of visibility around the vehicle that the driver desires.

Detailed Description Text (85):
According to the invention, since the display of the image by the display unit is decided to be necessary only in case where the width of the road detected by the distance measuring unit is equal to the predetermined reference distance or less and where the vehicle speed detected by the travel-condition detector is the predetermined reference speed or lower, the image around the vehicle is displayed on the display unit. Therefore, the image around the vehicle can be displayed on the display unit only when the width of the road is narrow and when the driver lowers the vehicle speed so as to watch around the vehicle.

Detailed Description Text (86):
Since the image pick-up unit is installed in the front end portion of the vehicle and used to pick up images in left and right directions in front of the vehicle, the left and right sides can precisely be confirmed at cross-shaped and T-shaped intersections by reference to the images picked up by the camera.

CLAIMS:

4. An apparatus for watching around a vehicle, the apparatus comprising:

an image pick-up unit mounted to the vehicle, the image pick-up unit for picking up an image on both left and right sides of the surroundings of the vehicle;

a display unit provided within the vehicle, the display unit for displaying the image on the left and right side,

an image control unit including:

an image pick-up unit power switch for turning on and off an operating circuit of the image pick-up unit;

an image output signal switch for turning on and off an image output circuit for converting the image signal from said image pick-up unit and supplying the image signal converted; and

a switch control portion having an upper threshold speed of a vehicle speed for turning on and off the image pick-up unit power switch and a lower threshold speed of the vehicle speed for turning on and off the image output signal switch,

wherein the switch control portion turns on the image pick-up unit power switch when it is detected that the vehicle speed reaches the upper threshold speed while the vehicle speed reduces; and

the switch control portion turns on the image output signal switch when it is detected that the vehicle speed reaches the lower threshold speed when the vehicle speed reduces.

8. The apparatus as claimed in claim 7, wherein the distance measuring unit detects the distance between the vehicle and each of the obstacles located on each of the left and right sides of the vehicle during the travel of the vehicle; and

the controller detects a space between the left-hand and right-hand obstacles on the basis of the distance between the vehicle and each of the left-hand and right-hand obstacles detected by the distance measuring unit, regards the space as width of a road on which the vehicle is traveling, decides whether or not the image on the display unit is to be displayed on the basis of the value of the width thereof, and controls the display unit to turn on or off the image of the obstacle on the display unit according to the decision.

9. The apparatus as claimed in claim 8, further comprising a travel-condition detector for accepting at least one vehicle signal for making a reduced vehicle speed detectable in vehicle signals indicating travel conditions which are output from a plurality of vehicle portions, and detecting the reduced vehicle speed according to the one vehicle signal, wherein

the controller decides whether or not the display of the image on the display unit is to be needed on the basis of the width of the road detected by the distance measuring unit and the result detected by the travel-condition detector, and controls the display unit to turn on or off the image of the obstacle on the display unit according to the decision.

10. An apparatus for watching around a vehicle as claimed in claim 8, further comprising a travel-condition detector for detecting vehicle speed by accepting a vehicle signal indicating a vehicle speed,

wherein the controller decides that the display of the image by the display unit is to be needed only in case where the width of the road detected by the distance measuring unit is equal to a predetermined reference distance or less and where the vehicle speed detected by the travel-condition detector is a predetermined reference speed or lower, and causes the image to be displayed on the display unit.

11. The apparatus for watching around a vehicle as claimed in claim 7, wherein the image pick-up unit is installed in the front end portion of the vehicle and used to pick up the image in left and right directions in front of the vehicle.

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L8	path or track or route	974980	L8
L7	L6 and l5	2248	L7
L6	(prevent$3 or reduc$3 or prohibit$3 or prohibit$3) near (speed or velocity)	47099	L6
L5	L3 or l2 or l1	43832	L5
L4	L3 or l2 nor l1	17356	L4
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L15	l13 and L14	2	L15
L14	resum$	96883	L14
L13	l5 and L12	38	L13
L12	l1 near L11	7799	L12
L11	speed	1983251	L11
L10	cruise adj control$	3510	L10
L9	L8 and l5	0	L9
L8	l1 same L7	15	L8
L7	resum$ adj speed	193	L7
L6	l4 and L5	0	L6
L5	yaw	17006	L5
L4	l1 same L2	7	L4
L3	l1 near L2	0	L3
L2	resume adj speed	125	L2
L1	inhibit$ or prevent$	4591618	L1

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